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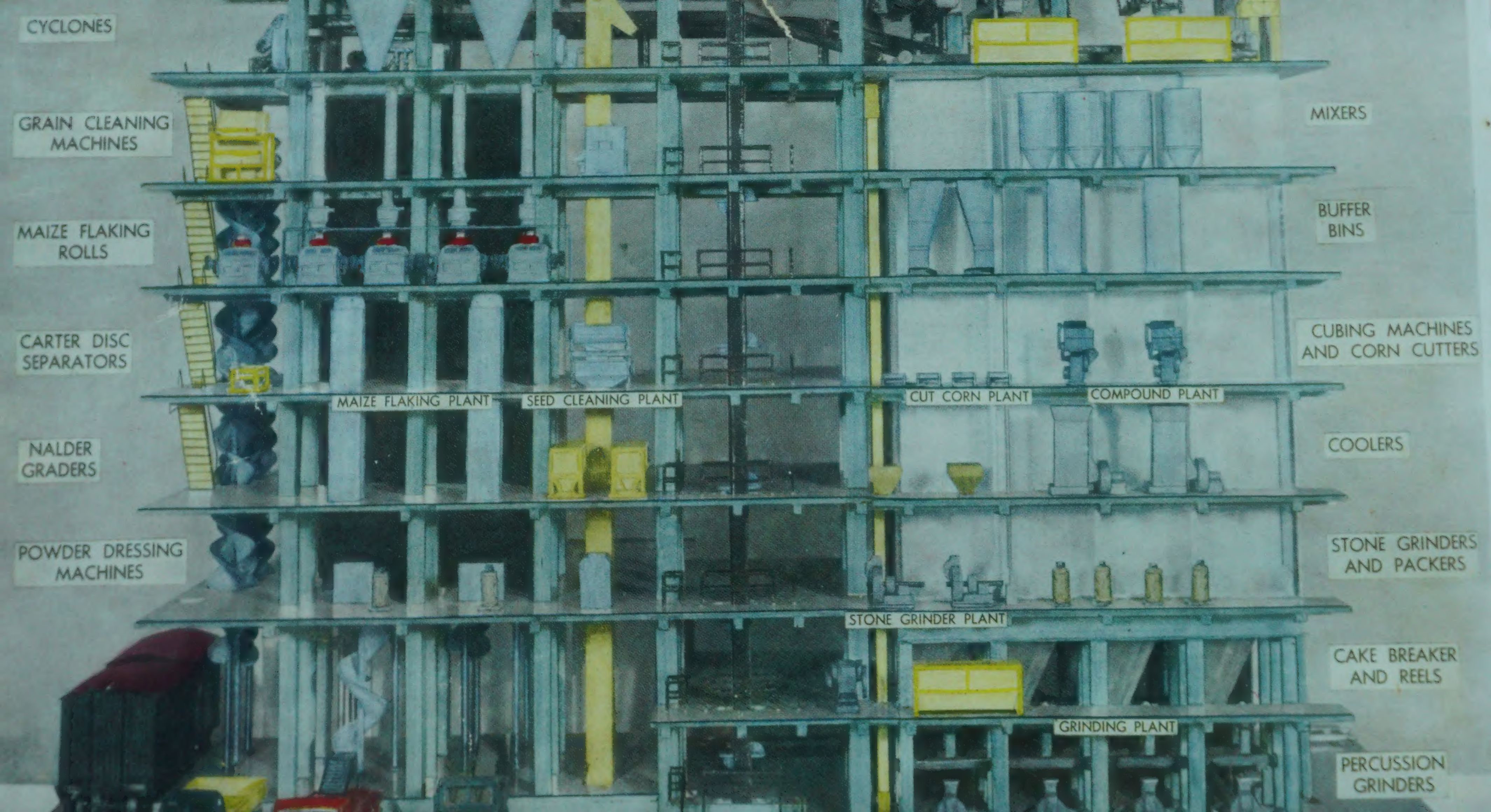
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MIXERS
BUFFER BINS
CUBING MACHINES AND CORN CUTTERS
COOLERS
STONE GRINDERS AND PACKERS
CAKE BREAKER AND REELS
PERCUSSION GRINDERS

COMPOUND MILLING

AND ASSOCIATED SUBJECTS

by

N. OWEN SIMMONS

Of Henry Simon Ltd., Cheadle Heath, Stockport, Cheshire. Examiner in Compound and Provender Milling for the City and Guilds of London Institute. Fellow of the Institute of Corn and Agricultural Merchants

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FOREWORD

By

J. F. Lockwood

Chairman and Managing Director, Henry Simon Ltd.

I AM glad to take this opportunity of welcoming Mr. Simmons as a fellow-author in the large and complex field of modern provender milling. From my own experience when I first ventured into this field some fifteen years ago I know how much time, thought and effort are needed to write a highly technical book of this kind; the task, however, is well worth undertaking, for provender milling is an important and rapidly developing industry, on which relatively little authoritative work has so far been published.

As a technical member of the staff of Henry Simon Ltd. for many years, Mr. Simmons has wide knowledge and experience of his subject; it is fair to add, however, that he has written in a purely private capacity and that the views expressed in this book are his alone and not necessarily those of Henry Simon Ltd.

I feel sure that a wide circle of those engaged in the provender and compound milling industry, whether as experts or students, will read this book with interest and benefit, and that in writing it Mr. Simmons has rendered an important and valuable service.

June, 1954.

J. F. L.

PREFACE

THIS book originates from a series of articles which appeared in *The Miller* from November 1946 until March 1950 under my pen-name of N. Owen. t was intended to publish the articles in book form at that time but there has been some delay, mainly because of the great deal of work involved. However, the articles have now been entirely re-written, enlarged and brought up to date.

In present times, food production from the land is of primary imporance. Many countries are striving to improve efficiency and to increase production by more modern methods. Inevitably, the compound and provnder milling industry or the processing of feeding stuffs for livestock is expanding throughout the world. So far, little has been written about this elatively new subject and it is hoped that this book will be of value to the ndustry.

The book is divided into two sections. The first section deals with the main points of interest to the compounder in relation to nutrition, the properties of feeding stuffs, the composition of rations, and the advantages of cubes and pellets.

The second and main section deals with all aspects of the compound milling process and the machines employed in it. Associated subjects also receive due attention ; these include the manufacture of ' straight ' feeding tuffs, the cleaning of grain for seed purposes, grain drying and condioning, grass grinding and cubing, cereal flaking and the processing of corn or poultry.

In making my acknowledgments, I wish to record that the publication f this book in such a form would not have been possible without the perission and kind co-operation of my Chairman and Managing Director, Mr. J. F. Lockwood, on behalf of Henry Simon Ltd. This is all the more ppreciated in view of his book *Provender Milling*, which is the only other ublication of its kind. Much of my information and many of my illusations have, of course, been acquired through my association with the firm.

In the preparation of the book, I owe a special debt of gratitude to Mr. . T. Johnson, M.A. Dip. Agric. (Cantab.), Education Officer of the Institute f Corn and Agricultural Merchants. In view of his authentic and up-toate knowledge of nutrition and the feeding stuffs themselves, I asked him re-write my original articles dealing with these subjects, and he is entirely esponsible for the written material of the first two chapters. Mr. Johnson has also done a good deal of work in reading and criticising all my previous rticles, and his constant help and advice over a long period have been of onsiderable assistance to me.

I am also grateful to Mr. Alan Ward, B.Sc., of Aynsome Laboratories for the information in Chapter III dealing with the composition of Compound ations; to Mr. A. G. Roberts and the technical members of the Provender Milling and other departments of Henry Simon Ltd., for checking my chnical data and helping with diagrams; to Mr. A. H. Rowles of

W. S. Barron & Son Ltd., for reading and criticising a number of chap particularly the one dealing with Grinders; to Dr. E. G. Woodroofe, behalf of the British Oil and Cake Mills Ltd., for permission to pul a number of photographs of their mills; and to *Progress*, the Unil magazine, for the coloured drawings of oilseed plants.

The following firms have very kindly supplied me with information illustrations :

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June, 1954. N. O. S.

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Chapter I

ANIMAL NUTRITION AND THE COMPOUND AND PROVENDER MILLER

THE major part of the produce from the farm lands of Great Britain is in the form of livestock products. Economy of production at every stage is of the greatest importance to the whole livestock industry. Good stock and efficient use of land, labour, equipment and feeding stuffs are necessary. To the last of these—efficiency in the use of feeding stuffs—the compound manufacturers and provender millers can make a substantial contribution. To do so their products must not only be good materials in themselves, but must correctly supplement the foods grown and consumed on the farms, and they must do this whilst, at the same time, bringing into use, with the maximum economy, every suitable feeding stuff. Some are obtainable only intermittently and in fluctuating quantities : many require processing in various ways to make them suitable for feeding to farm animals : all can be made to yield better returns in animal products by appropriate combination with other foods. By seeking out new or little known materials, by skilful processing, which includes the removal of harmful impurities, and by combining a great variety of substances in the correct proportions for the different uses on the farm, the compound and provender milling industry performs an indispensable service to modern agriculture.

Scientific study of animal feeding has revealed the main principles upon which the nutritional processes operate. It is, however, important that the limitations as well as the wealth of present knowledge be recognised. Many gaps have still to be filled and in some directions only the fringe of the problems appears to have been reached, notably in the field of minerals, vitamins and ‘ antibiotics ’. Consequently, the care and feeding of animals on the farm still demands those qualities of observation and personal judgment that constitute an art rather than a science. Nevertheless, the science of nutrition has provided sufficient information on the functions of food to make calculation of food requirements for specific purposes practicable and reliable. It has shown the compound and provender manufacturer how to combine his various materials in effective and economical proportions.

It is not the purpose of this book to deal with the general subject of nutrition, but there are points of particular significance to the manufacturer of animal feeding stuffs that call for special attention.

BALANCED RATIONS

The term ‘ balanced ration ’ is very widely used to denote any mixture f feeding stuffs of the concentrate class in which the ingredients are proortioned so as to provide a specified starch equivalent/protein ratio. It is sometimes even taken to imply that the mixture contains in correct proportions *all* the animal's nutritional requirements.

This use of this expression has undoubtedly led many people to think only of the composition of the concentrate portion of the animal's daily intake, ignoring or paying too little attention to the feeding value of the hay, roots, silage, pasture, etc. There is little to be gained by attending to the nutritional ' balance ' of one portion only of the diet : it must be considered as a whole. The proper meaning of the word ' ration ' is a quantity of food for a specified period, e.g. 12 lb. hay, 40 lb. mangolds and 7 lb. concentrates per day, and so on. If the description ' balanced ration ' is intended to mean that the composition of a particular compound or prepared mixture is such as to supplement correctly the other components of the whole ration, then a better description would be ' balanced supplement ', or even ' balanced compound '.

MINERALS

For a comprehensive study of the mineral requirements of farm animals, reference should be made to the existing literature. In this place an attempt will be made only to summarise present knowledge as it bears on the question of incorporating mineral elements in prepared mixtures or compounds.

The mineral requirements of farm animals cannot yet be stated with precision. Enough is known about them to show that the animal body cannot function normally if its minimal needs are not provided, but there are differences of opinion amongst nutrition scientists on the question of whether or not mineral supplements containing all the known essential elements should be added to compound feeding stuffs. In favour of their inclusion it is argued that full health, growth and production may often not be achieved because of small deficiencies which are not detected ; and that the quantities of most of the mineral elements that need be included in mixtures for feeding are so much smaller than any known harmful dosages that the safety margin is big enough to preclude any risk.

Complete mixtures of minerals in the compounds provide a measure of insurance against deficiencies. It is admitted that, with the exception of the four major elements, calcium, phosphorus, sodium and chlorine, the probability of more than one element being deficient at one time is remote ; but a point is made of the practical difficulties of manufacturing a great variety of mineral supplements to comply with the special conditions in every district.

The case against the inclusion of complex mixtures in compounds appears to be rather stronger on scientific grounds. In Great Britain pronounced mineral deficiencies are uncommon and, so far as has been established, are associated with only a few elements. The interaction of mineral elements in the food has as yet hardly been investigated but the inactivation of some elements by others is known to occur. Until research has thrown more light on these problems the throwing in of ' some of everything ' has little scientific support. Where deficiencies are known and the effective remedy has been discovered, there is no evidence that a mixture of all the ‘ essential ’ elements shows any advantage over the single one that is deficient. A well-known example is that of cobalt. In parts of Scotland, on Dartmoor and elsewhere, the disease of sheep known as pining, vinkish or moorcling, is now cured by very small additions of cobalt sulphate to the food. No further advantage is derived in these cases from feeding a ‘ complete ’ mineral mixture.

The discovery of these ‘ deficiency areas ’ gives point to another argument against complex mineral mixtures being put into compounds. They emphasise the great differences in chemical composition of the herbage and other crops that exist on farms, requiring different mineral supplementation. It may be possible to provide a range of mineral supplements—that is a problem for the manufacturer—but if the compounder, already producing a considerable number of compounds for the various types of livestock, has to multiply his range of products by the number of mineral mixtures required, he is clearly complicating his compounding processes and thereby increasing their cost for a dubious advantage. The study of mineral nutrition is still in its infancy : until practical experience and scientific research can give more certain guidance the compounder and provender miller may prefer to rely upon the great variety of ingredients in his products to ensure a good balance of minerals.

Of the eight mineral elements that are required by the animal in relatively substantial quantities, four are normally amply supplied in the mixed diet of the farm. They are potassium, sulphur, iron and magnesium. In particular circumstances the last two may fall short of the animals’ needs and it is then necessary to make special provision for them.

The need for calcium, phosphorus, sodium and chlorine, however, can easily exceed the amounts that the animal can extract from its ordinary food, particularly when high production is being maintained. Even though these elements are available, neither the cow nor the hen appears to be able to assimilate them fast enough to balance losses during periods of high output of milk or eggs. Calcium and phosphorus are stored in the body whilst production is low, but there is no storage of sodium and practically none of chlorine, any surplus to immediate needs being excreted. There is therefore sound scientific support for the practice of giving a mineral supplement containing calcium, phosphorus, sodium and chlorine to young, growing animals and to milking and laying stock. What quantity to feed has to be decided somewhat empirically for several reasons. The mineral content of the foods in use at any time on the farm can, at the best, be only very roughly estimated, differences between the needs of individual animals are an unknown factor, and knowledge of the utilisation of the different chemical forms in which minerals occur in foodstuffs is still lacking. Fortunately, animals appear to be able to adjust the balance of these four important elements if there is enough of each available and the excess, if any, is not too great. Because of this adaptability, mineral supplements supplying calcium, phosphorus, chlorine and sodium can be prepared and fed to farm animals with reasonable assurance that their requirements will be satisfied. The classes of livestock that are commonly in need of these additional minerals under British farming conditions are rapidly growing young animals, including poultry, laying hens and heavy-milking cows. Even so, some consideration should be given to the probable daily mineral intake and to apportioning any supplement at least approximately to the conditions at the time.

VITAMINS

The manufacturer of feeding stuffs should understand the conditions leading to vitamin deficiencies in order that any provision he may make to supply the required substances may be effective and that he may not increase the cost of his products by unnecessary additions. There is here a close parallel with the question of mineral supplements.

Vitamin deficiency amongst farm livestock is the exception, not the rule. Green foods, grass, kale, sugarbeet tops and so forth, supply adequate quantities of vitamins, with the exception of vitamin D, but under some systems of management farm animals may not obtain enough of the vitamins A and D, and, more rarely, vitamins of the B complex, such as riboflavin. Deficiencies are most likely to occur amongst young, growing animals and breeding stock.

VITAMIN A

Farm animals can, and normally do, depend entirely upon the crops grown on the farm for their requirements. The vitamin itself is not found in plants, but the substance known as carotene occurs in the green and, in certain species, in other parts. From the carotene in their ordinary food animals form the vitamin A they need. Moreover, they are able to store large reserves of this vitamin, principally in the liver, so that the abundance of green food in summer supplies most of their needs for the whole year with only a very small contribution from the winter foods. Under some conditions this may not be possible, and the manufacturer of feeding stuffs has to consider whether he may be able to fill the gap. The discovery many years ago that certain fish liver oils, principally cod and, later, halibut, were rich in vitamins A and D, led to their universal use as the only known large sources of supply, and this continued for a long time. Under the war time Statutory Rules and Orders compounders were compelled to include specified percentages of cod-liver oil in certain products. A few years ago it was shown, however, that the active properties of vitamin A were lost when the oil was exposed for long to the air and that as a consequence the mixing of cod-liver oil with feeding stuffs in the course of their manufacture was unsatisfactory. Other means of supplementing feeding stuffs with the vitamins were explored and, with the successful analysis of its chemical composition, the commercial manufacture of vitamin A became possible. There are now synthetic preparations available which do not lose their potency when incorporated in meals and compounds.

Attention has also been given to the preservation of carotene by artificially drying young grass or other fresh green crops. The carotene value is at its highest when the leaf is young and green, and if the crop is cut at this stage and quickly dried down to about 12 per cent of moisture, two-thirds or more of the carotene is retained undamaged. The conditions of storing the dried material, however, are very important because oxidation quickly destroys the carotene. The rate of deterioration is checked by the exclusion of air and by cool storage. The loss of carotene from dried grass can, under bad conditions, be as severe as the loss of vitamin A from cod-liver oil. If dried grass is efficiently made, cooled and stored in such a way as to exclude air, it may retain 50 per cent or so of its carotene for many months. It might be expected that such methods as the high-pressure baling of dried grass or the cubing of dried-grass meal might be successful in preserving the carotene value. From experimental evidence it appears probable that high pressure baling is beneficial but the heat produced in grinding dried grass causes some loss. More experience is wanted of the efficiency of cubing.

VITAMIN D

This vitamin is particularly important to all young animals because of its influence on the assimilation of calcium and phosphorus.

Several forms of vitamin D have been discovered. The two which are of importance on the farm are D_2 and D_3. D_2 is formed when plant material containing the substance ergosterol is exposed to ultra-violet rays, as in the making of hay in sunlight. D_3 is formed in the animal from substances in the skin under the action of the same rays. Even though the sun may be behind the clouds, the exposure of the skin to bright daylight brings about the formation of vitamin D_3, but ordinary window glass obstructs ultra-violet rays. Lack of this vitamin amongst farm stock is not likely to occur, therefore, except when they are kept entirely indoors, as in the case of battery-reared chicks or poultry and pigs kept under intensive conditions. For all animals kept in confinement a source of vitamin D must be provided. The D_2 form, though satisfactory for other stock, is almost useless with poultry. It is essential, therefore, that the source of any vitamin D preparation for poultry be carefully ascertained. Cod-liver oil has been the principal medium but both D_2 and D_3 are now manufactured commercially and the synthetic preparations, which are very potent, can be used to fortify or to replace the natural substances. Cod-liver oil contains a form of vitamin D that is similar to the D_3 form in that it is effective in preventing rickets in chicks. Irradiated yeast is rich in vitamin D_2 and valuable for pigs, but is unsuitable for poultry.

Vitamin D is not as quickly destroyed as vitamin A by exposure to the atmosphere but traces of copper and iron or contact with alkaline materials can break it down (3), therefore pre-mixing cod-liver oil with feeding stuffs is not an entirely safe method of administering vitamin D, quite apart from the loss of vitamin A.

VITAMIN B

Vitamins of the so-called B complex, are widely distributed in the common farm feeds. All the green crops, grasses, clovers, cabbages and good silage are well supplied and good quality hay is a satisfactory source. Amongst the concentrates, dried yeast, wheat offals, particularly wheat germ, and rice meal are rich in these vitamins whilst oats, barley, beans, peas and the oil seeds and their cakes provide some.

Ruminants are not dependent upon their food for vitamin B because it is developed in the rumen by the action of bacteria. It may be noted that the rumen of a calf is not functioning fully until about four weeks of age and consequently the young animal's requirements for vitamin B must be supplied in its food. The rations of poultry and pigs when kept indoors without access to fresh green food should be chosen so as to include some of the foods mentioned above. Riboflavin, one of the B vitamins, is particularly important in the diet of young chicks and hens laying eggs for hatching. Liver meal, dried yeast, dried separated milk, dried whey and good quality dried grass are the best sources of riboflavin.

Several of the substances included in the group of vitamins collectively referred to as the B complex are now being prepared synthetically. They are reliable and provided their separate use does not result in the omission of one or more that would have been supplied in such materials as dried grass, dried yeast or dried milk powder, they should become a valuable and economical form of rectifying deficiencies.

The most recent addition to the B group is B_{12} which has been given the name Cobalamin because it contains a small amount of cobalt. It is closely associated with other, unidentified substances which collectively have been described as ' the animal protein factor '. Knowledge of the action of this vitamin is still too imperfect to substantiate general recommendations on the inclusion of particular materials in rations. The very young of all species of animals are most likely to suffer from lack of B_{12} or the whole animal protein factor, but their need for it ceases at about the weaning age. Calves have been shown to make normal growth when no animal protein was fed after the age of four weeks. Pigs which have had no animal protein after weaning have maintained normal live weight increases. Chicks grow more slowly for the first six weeks when no animal protein is fed, although they make good the difference in growth by the time they are five to six months old. Until more exact knowledge and confirmation of experimental results are available the inclusion of some animal protein in the rations of young animals is a safeguard against deficiency.

ANTIBIOTICS

The discovery of this group of substances and their effects on animal growth have attracted much attention at a time when high prices of feeding stuffs have accentuated the need for even small improvements in the ratio of food consumption to live-weight gain. More research is necessary before the use of antibiotics can be put on a sound basis: at present it is not known how their effects are brought about. The position at the present time can be briefly summarised:

1. Beneficial effects are confined to quite young animals during the period of rapid growth.
2. Animals that are free from germs, as when chicks are housed in new and, therefore, germ-free houses, show little or no response to antibiotics.
3. Animals receiving good quality animal proteins, e.g. white fish meal, derive less benefit from antibiotics than animals fed on all-vegetable diets.

4. Under most farm conditions antibiotics have given better growth in young animals.
5. Improvement in the efficiency of food utilisation has been rather less definite than improvement in growth rate.

The future of these new materials in the feeding of farm animals cannot be assessed with certainty: longer and more varied experience of their effects is required. They should, however, be watched closely by the manufacturer of feeding stuffs.

Chapter II

THE PRINCIPAL FEEDING STUFFS USED IN THE MANUFACTURE OF COMPOUNDS AND PROVENDER

CEREALS

BARLEY

Barley is a safe and easily digested food for all livestock when correctly balanced for proteins, minerals and vitamins by other ingredients of the ration. It is essentially a starchy food, low in oil, and when it forms a substantial part of the diet it produces fat of excellent quality. It is entirely satisfactory when forming part of a balanced milk or egg production mixture, but, like all starchy foods, it cannot give good results if it is not properly balanced by other foods.

Barley is a hard grain and should be ground or crushed for all animals. If fed whole to cattle, or even pigs, a proportion of the grain escapes mastication and passes out in the faeces undigested. Poultry can use the whole grain but it is important to ensure that the awns are fully removed, because they can cause trouble.

The bushel weight of barley, as of other grains, gives an indication of its quality. It varies from 56 lb. down to as low as 43 lb. per bushel.

BARLEY BY-PRODUCTS

The husk and bran, detached in the manufacture of pot and pearl barley, are recovered as dust, of which three grades are obtained: fine, medium and coarse. Their composition is approximately:

	Crude fibre per cent	*Crude Protein* per cent	*Carbohydrate* per cent
Fine dust	4-5	11-12	65
Medium dust	13	12	49
Coarse dust	26	6	52

The fine dust is a useful ingredient in pig and poultry foods. The coarser, more fibrous grades are best suited for cattle and sheep.

If the three grades are mixed in the proportions in which they are obtained from the grain, the composition of the composite dust, known as barley feed, is as follows:

Crude Fibre per cent	*Crude Protein* per cent	*Carbohydrate* per cent
8-9	12-13	60-62

BREWERY BY-PRODUCTS OF BARLEY

The effect of the first stage in the chain of operations by which alcohol is obtained from barley is to cause the grain to germinate and commence growth, which has the effect of converting most of the starch into the sugar maltose. Growth is stopped by kiln-drying the sprouted grain when the young shoot and rootlet are about one inch long. The dried shoots and rootlets are screened off and are known as malt culms.

MALT CULMS (or COOMBS)

The quality of malt culms is variable and only those in good condition should be used for feeding. Any mouldy or off-flavour lots should be directed to the fertiliser trade.

The fibre of malt culms is very well digested by cattle and they are a useful ingredient in compounds. It should be noted that, of the 24 per cent of crude protein, only about half is in the form of digestible true protein and the protein equivalent works out at about 16 per cent.

Attention should also be drawn to the manner in which dried malt culms swell in the stomach: for this reason the daily quantities given to farm horses should not exceed 6 lb., or cows 4 lb.

BREWERS' GRAINS

The malt sugar, to be later converted into alcohol, is extracted in the mash tun, from which the wort, containing the sugar in solution, is run off, leaving a residue of *wet brewers' grains*. When dried to 10 per cent of moisture these contain about 15 per cent of fibre, half of which is digestible by ruminants. The protein equivalent is between 12 and 13 per cent and the nutritive ratio about 1:4. They are therefore ' balanced ' for milk production and are a useful food for this purpose. Their bulkiness and high fibre content make them unsuitable for pigs, though small quantities can be fed with good results to sows and to pigs from about 100 lb. live-weight.

DISTILLERS' GRAINS

Distillers' grains are derived from a comparable process in the distillation of alcohol. The slightly different operations and materials give rise to a residue that, though not as palatable, is richer in protein and lower in fibre. Average figures for dried distillers' grains are:

Fibre		Protein		Oil	
Crude	*Digestible*	*Crude*	*Dig. True*	*Total*	*Digestible*
per cent	per cent	per cent	per cent	per cent	per cent
10	5	28	20	11	10

BUCKWHEAT (*Fagopyrum esculentum*)

In comparison with the true cereals, buckwheat contains more fibre—buckwheat 15 per cent, oats 10 per cent. In other respects it is of similar composition and can be used as a partial substitute, provided that its rather lower starch equivalent be taken into account.

It has, in the past, been regarded chiefly as a poultry food but it can be incorporated in mixtures for cattle with satisfactory results.

DARI OR SORGHUM (*Sorghum vulgare. Andropogon sorghum*)

The sorghums are grown in many parts of the world where the climate is hot and dry. There are many varieties, but the composition of their grain does not differ enough to affect the feeding qualities seriously. They are variously known as durra, milo, kaffir corn, sorghum, dari, etc. The type known as Guinea corn is distinguished by having the glumes attached to the seed, giving it a characteristic pointed oval shape and a highly polished, golden brown surface. The sorghums other than Guinea corn have a starch equivalent of about 74 (cf. maize 76-77): the greater fibre content of Guinea corn (5-6 per cent) brings down its starch equivalent to about that of barley (71 per cent).

Sorghum can be used in any mixture as a cereal, its special features being its high starch, low fibre and low mineral content.

MAIZE (*Zea mays*)

Two varieties of maize are in general use as feeding stuffs, horse-tooth or dent maize and flint or round maize. Though flint maize is the harder of the two, both types are too hard to be utilised economically if fed whole. Even for feeding to adult poultry maize should be kibbled, for which purpose there seems to be some preference amongst poultrymen for the flint or round type of grain.

For all other stock maize should be ground to a meal. It may be noted that maize contains 4 per cent of oil which tends to become rancid when maize meal is stored for any length of time. Most of the oil is contained in the germ and when the germ is removed the oil content of the degermed maize meal is reduced to about 1·5 per cent.

Maize has the highest starch equivalent of all the cereal grains. It contains little fibre or mineral matter and is particularly poor in calcium. Its protein is not only low in quantity but, by itself, is biologically of poor quality, being deficient in tryptophane, an important amino-acid. These characteristic deficiencies of maize must be made good by combining it with other foods that supply the missing factors: if this is not done the high productive value of the maize cannot be fully utilised. Provided its composition is taken properly into account, maize is one of the most valuable foods for all classes of livestock. In addition to the consideration of nutritional deficiencies and their correction, a limit is set to the amount of maize that can be included in a mixture, firstly by the necessity for providing sufficient fibre to maintain a satisfactory physical texture in the food and, secondly, by the effect of maize upon the quality of the carcase. Too high a proportion of maize in the ration produces a soft fat that is not liked by the British consumer. The yellow colour of yellow maize is also transmitted to the fat of the animal if too much of this grain is consumed.

Yellow maize contains a substance, cryptozanthine, which, like carotene, is transformed by the animal into vitamin A. The amount present, however, may be small and maize cannot be regarded as a reliable source of vitamin A.

FLAKED MAIZE

Flaked maize is produced by steam cooking the whole or cracked grain and then passing the hot, soft grain between rollers. The flattened grain is then dried to a crisp flake and cooled. There may be a small reduction of oil, mineral matter and fibre, but the substantial increase in digestibility and, of equal importance, palatability, far outweighs any such losses. The net result is to raise the figure for starch equivalent from 78 to 84. The physical condition of the flakes undoubtedly contributes to their palatability and to the fondness displayed by farm animals for this type of food. To obtain the full benefit of flaking, care should be taken to preserve the fresh condition as much as possible up to the time of feeding to the animals.

If supplies are adequate, flaked maize can be included with advantage in the rations of all livestock. It is particularly valuable as a highly concentrated, highly digestible carbohydrate for young pigs, lambs and young cattle being fattened at an early age, heavy milking cows and young horses. When prices or quantities limit its use, flaked maize should be reserved for these classes of animals.

The paucity of maize in minerals, and, in fact, in almost all nutritive elements except carbohydrate, must not be overlooked when economic conditions lead to its use in large quantities.

BY-PRODUCTS OF MAIZE

Maize starch is the foundation of important commercial products, such as corn-flour, glucose and starch. Maize oil also enters into the manufacture of soaps, margarine and other commodities. The processes of separating the starch and oil leave behind several residues that are valuable as animal feeding stuffs.

Maize Germ Meal derived from this source retains about one-third of the oil present before processing, the figure given in the Ministry's Bulletin *Rations for Livestock* (1) for digestible oil in maize germ meal being 11·5 per cent.

Maize is also used in the brewing and distilling industries and a maize germ meal is produced, but by a different process that does not involve floating the germ off in water. The two forms of maize germ meal may be compared on the basis of the figures shown below.[1]

	From Starch Works per cent	*From Dry Process* per cent
Moisture	11·5	12·0
Protein	21·5	10·0 [2]
Oil	10·0	11·0
Carbohydrates	49·5	58·8
Fibre	6·0	7·0
Ash	1·5	1·2

In the dry method of separating the germ from the maize grain, much of the bran may accompany the germ, thereby reducing the percentage of oil. Since the amount of oil present has a considerable influence on the nutritive character of the meal, an analysis is to be recommended.

Maize germ meal is readily eaten by all farm livestock, but its high oil content makes its inclusion in the food of fattening pigs undesirable because of its softening effect on the animal fat. It combines well with feeding stuffs of low oil content and is most useful in the feeding of high yielding cows.

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[1] From *Animal Nutrition and Veterinary Dietetics*, Linton and Williamson (2nd ed.).

[2] In some samples it has been recorded as low as 7 per cent.

Maize Gluten Feed. The composition of maize gluten feed as marketed is liable to vary to some extent on account of differences in methods of processing. The chemical composition of maize bran, maize gluten meal and of the mixture of these two known as maize gluten feed, can be seen in the Tables of Composition. These are, of course, average figures and the analysis of any particular lot depends upon the amount of starch that has remained after the starch extracting process.

Maize gluten feed is well digested by all farm animals and is suitable for inclusion in all mixtures. It may be noted that its nutritive ratio is correct for milk production so that it may be added in any proportion to a milk production mixture. It must be remembered, however, that the proteins of maize are lacking in some amino-acids and that maize is very deficient in calcium. Moreover, although easily digested, maize gluten feed appears not to be very palatable to farm animals. It should not, therefore, form too large a part of a mixture or compound : depending upon the particular quantities of the other constituents, a maximum of 20-25 per cent is advisable.

MILLET

Millet, of which there are many varieties, has been used almost exclusively as a poultry food in this country. In composition and nutritive value it closely resembles oats and, should supplies be available, it could very well be included as an ingredient in compounds or mixtures in place of ground oats.

OATS

Like barley, the oat grain retains the husk when threshed from the ear. In the case of barley this is usually termed the skin and it accounts for 8-16 per cent of the weight of the grain. The husk of oats, though not as tightly shrunk on to the kernel as is the skin of barley, is much thicker and constitutes a little over 20 per cent of the weight of the grain in very fine ' skinned ' varieties, up to 35 per cent, or even more, in the coarsest samples.

The husk consists largely of fibre, about 33 per cent, much of which is indigestible. For this reason the feeding quality of oats depends to a great extent on the proportion of husk. A high husk figure is characteristic of most foreign oats. This character is one that should be closely watched.

The colour of the oat husk may be of considerable importance to the oatmeal miller but it bears no relation to the feeding value of the whole oat. Plumpness, firmness and freedom from mustiness, combined with a low husk weight, are the features that are of importance to the feeding stuffs manufacturer. The kernel should be white, firm and fresh to the taste and smell. Oats that have become musty can be very harmful to animals and should not be accepted by feeding stuffs manufacturers.

The bushel weight is indicative of feeding value in that low bushel weights are always associated with thin, badly filled kernels and high proportions of husk. Weights of very good samples may be about 46 lb. per bushel and poor samples may weigh as little as 35 lb. or even less, 30 lb. samples being met with in some shipments. A good average sample should weigh about 40-42 lb. to the bushel.

Oats are such a safe food (except during the first three or four months after harvest, when they must be fed with great care) for cattle, sheep and horses, that the only restriction on their use, other than price, is the necessity for balancing the ration and for keeping the bulk within the capacity of the animal.

The high fibre content of oats may be a disadvantage when they are included in the rations of pigs or poultry. Whole oats are given to laying hens, up to as much as 50 per cent of their grain feed, but only oats of high bushel weight should be used, and, preferably, they should be clipped so as to remove any fragments of awn and the pointed tips.

OAT BY-PRODUCTS

The processes employed in preparing oats for human consumption result in the separation of several portions of the outer part of the oat grain. All contain a high proportion of fibre and in some instances a considerable amount of earthy material. These by-products, which accumulate at different stages in the milling operations, are sometimes mixed before sale. In any case feeding stuffs manufacturers should have these materials analysed before using them, if only as a guide to the most suitable combination with other foods. Their high fibre content can be offset by such low-fibre feeds as tapioca flour, sorghum, rye meal, maize meal, etc. The oat fibre, though of low digestibility in itself, reduces the ‘ stodginess ’ of these very floury foods and thereby makes for better digestion of them.

The name Sussex ground oats is applied to oats that have been ground to a particularly fine meal. Specially good samples are produced by removing some part of the husk before grinding. The addition of a small amount of barley facilitates fine grinding and is sometimes included for this purpose. The fine grinding enables pigs, and probably also poultry, to make better use of the fibre of oats.

RICE

The whole grain is seldom if ever offered as an animal feeding stuff in this country. It is not, in any case, a very safe food because the husk contains a high proportion of silica and if crushed with the grain it forms sharp, glass-like particles that are reputed to be injurious to the mucus membrane of the alimentary organs.

Small rice and broken grains are often included in grain mixtures for chickens. In feeding value they are comparable with feeding quality barley.

Polished rice is perhaps the nearest approach to pure starch in the form of a foodstuff.

RICE MEAL

The first process in the preparation of rice for human consumption is the removal of the very hard husk. This leaves the kernel enclosed in the bran layer which, in turn, is detached together with the germ. Finally, when polished rice is required, the kernels are passed through another operation which produces a third by-product, rice polishings or ‘ rice polish ’. Rice meal is the ground bran to which there has usually been added before grinding some small, whole rice grains. The polishings may also be included and, in some samples, a proportion of the hulls or husks has been ground with the bran.

Rice meal is therefore liable to show considerable variation in composition and it is important that a watch be kept on the silica content as a check on the inclusion of the rice hulls.

Rice meal is very rich in oil—12-18 per cent—and, as it becomes rancid somewhat easily, the conditions of transport and storage are important. The oil has a low melting point and has a marked softening effect on the bodyfat of pigs and cattle and on the butterfat of milk. The calcium/phosphorus balance is poor, calcium being very low and phosphorus high.

Rice meal is a good source of some of the B group of vitamins.

Provided attention is given to the oil and silica content, rice meal is a valuable carbohydrate material for use in compounds.

Its variable composition makes it less satisfactory for feeding to young than to older animals.

Rye

In chemical composition and nutritive value rye is practically the same as wheat and, subject to the limitations that follow, it can replace wheat weight for weight in mixtures. Rye has certain properties that necessitate special care in its use. It is much more susceptible than other cereals to infection by the fungus ergot, which may cause abortion if eaten by pregnant animals. It is a very unsafe food when new, that is, in the autumn and winter following harvest. It is not liked by farm animals and, whilst this is to some extent a safeguard, it should not form more than 15 per cent or at the most 20 per cent of the concentrates. It is not suitable for young stock at any time.

Wheat

Although the chemical composition of wheat, as shown in the standard tables of composition, is not markedly different from that of other cereals, wheat has certain characteristics that affect its use as a feeding stuff.

The whole, unbroken wheat berry can only be fed with success to poultry, and even for chickens under eight weeks old it must be cut or kibbled. For all other animals wheat must be ground, crushed or soaked because the grain is too hard to be properly masticated. The grinding should not be finer than a coarse meal; finely ground wheat becomes pasty in the mouth and unpalatable and, if swallowed in lumps, is very indigestible. This applies to all livestock, including poultry.

Wheat can be included in the concentrates for cattle up to 25 per cent. Pigs can be allowed up to 30 per cent and poultry up to 50 per cent. At these high rates, however, there are advantages in the use of more than one cereal, particularly if wheat bran or middlings form part of the meal mixture. Wheat can be given to horses as part of their cereal food but it is said to cause laminitis. It must be coarsely crushed or rolled.

By-products of Wheat Milling

The object of flour milling is to separate the flour, i.e. the starchy endosperm, from the other portions of the grain. The extent to which this is accomplished depends upon (*a*) the efficiency of the milling operations and (*b*) the proportion of the grain that is taken out as flour, i.e. the extraction rate. Modern flour-milling has reached a very high level of technical efficiency and greater differences in the composition of the by-products of wheat-milling (wheat offals) are to be expected from changes in the extraction rate than from variable results of milling operations.

Before 1939 the usual proportion of the wheat grain extracted as flour was about 70 per cent, leaving 30 per cent of the grain in the form of offals or ‘ wheatfeed ’. Many names have been used to designate the various by-products, e.g. bran, pollards, sharps, thirds, coarse middlings, fine middlings, etc., and a good deal of confusion has resulted from the indefinite classification of the materials. The grades generally recognised just before 1939 were:

Flour, which consisted entirely of the endosperm, composed of starch and gluten.

Superfine weatings or superfine wheatfeed (fine middlings) consisting of the most finely divided particles of the inner layers of the seed coat, together with a small amount of flour.

Fine wheatfeed, or, if home-produced, *weatings* (coarse middlings) separated from the bran by a coarser sieve than the previous grade.

Bran, the outer layer of the seed coat.

The grade that formerly was produced between coarse middlings and bran was ‘ pollards ’. It was discontinued between the wars, part going into the bran and part into coarse middlings. The nutritive properties of these grades may be judged from their chemical composition. Average samples would show, on analysis, figures for the main constituents as follows:

	Fine Middlings	*Coarse Middlings*	*Bran*
Crude protein	17	16	14½
Oil	4	4½	4
Carbohydrates	61	56	52
Crude fibre	2½	6	10
Ash	2½	4	6
Total dry matter	87	87	87

Frequently two, or three, of these grades were mixed and sold as ‘ straight run middlings ’, or, in the days when the grade known as pollards or coarse sharps was produced, ‘ straight run pollards ’.

In the early nineteen-thirties an attempt was made to standardise the grades of wheat offals, or wheatfeed. Three grades were prescribed: *Superfine Weatings*, guaranteed to contain not more than 4½ per cent of fibre, *Weatings*, to contain not more than 5¾ per cent, and *Bran*.

Superfine Weatings, as a grade, was discontinued as a result of the raising of the extraction rate of flour. When the extraction rate was at 81 per cent or more the fraction of the wheat left for animal feeding contained very little of the starch or even of the aleurone layer. Middlings, or fine wheatfeed, were replaced by fine bran, which has a feeding value little if any higher than that of coarse bran. Woodman (1) gives the following figures. The corresponding figures for oats are given also for comparison :

	Fibre per cent	*Digestible Protein* per cent	*Starch Equivalent* per cent
Coarse bran	10·3	11·0	40·4
Fine bran	9·4	10·8	44·0
Oats	10·3	8·0	59·5

The higher starch equivalent of oats comes from the oat endosperm and the oil—4 per cent. It is clear that no big differences in feeding value are likely to be found between coarse (or broad) bran and fine bran, and experience confirms this conclusion.

BRAN

Bran has two dietetic properties that confer on it a value apart from its nutrient content. For every class of livestock it is a safe and effective medium for lightening heavy, dense food mixtures, making them more palatable and facilitating their digestion. Bran also is one of the safest laxatives and can be used for this purpose for all animals. It is most effective if scalded and given as a warm mash; but even dry bran has a laxative action if ample drinking water is supplied.

As a feeding stuff bran is deficient in calcium and if it is regularly included in the ration this deficiency must be made good. It is a good source of vitamin B and a fair source of vitamin E.

The amount of bran that should be included in pig mixtures is limited by its bulkiness. For pigs its principal use is as a laxative for in-pig sows and gilts (7), for which particular purpose it may constitute as much as 50 per cent of the ration if the other half is inclined to be costive in its effect. It is given to boars for the same reasons but bran is rarely an economical food for bacon or pork pigs.

Very similar considerations govern the feeding of bran to poultry. For lightening mashes for poultry of all ages, bran is included in proportions up to 15, 20 or even 25 per cent of the mash.

WEATINGS (Middlings)

Both the fine and the coarse grades are fed to all farm animals, but they are particularly favoured for pigs and poultry. The rations of young pigs at weaning frequently include 45 per cent of weatings, which is gradually reduced and replaced by barley meal or other cereal meal until by the time the pigs have reached some 140 lb. live-weight the proportions of cereals are about 80 per cent of other cereal meal with 20 per cent of weatings.

For poultry, weatings are regularly included in mashes for all ages, and often constitute 40 per cent of the ration.

Weatings are also useful in mixtures for dairy cows.

As would be expected, weatings are low in mineral matter, particularly calcium. They do not retain as much of the vitamins as the bran but are nevertheless a useful source of the B group.

LEGUMINOUS SEEDS

The seeds of legumes used as food for farm animals, with a few exceptions, belong to the class of medium-protein concentrates, average crude protein percentages being:

	per cent
Field beans	25
Gram	23
Lentils	25
Peas	22
Vetches	26

Two exceptions that may be noted are:

	per cent
Locust bean—	
(pods with seeds)	6
(pods only)	4
Sweet lupin seed	42

The proteins of the legumes contain most of the essential amino-acids, and are therefore of good biological value. They supplement effectively the amino-acids of the cereals ; and mixtures of cereals and legumes supply what may be termed ‘ balanced proteins ’. It has long been known from practical experience that a mixture of equal parts of beans and oats is a good milk production concentrate: the complementary nature of the proteins is, perhaps, one explanation of the success of this combination of foods and of the popularity of beans and peas for young growing stock.

Mineral Content of Seeds of Legumes, compared with Cereal Grain and Dried Green Crops

	Calcium Oxide CaO	*Phosphorus* P_2O_5	*Potassium* K_2O	*Chlorine* Cl	*Calcium Phosphorus ratio* CaO : P_2O_5	
Leguminous Seeds						
Beans	0·18	0·88	1·28	0·03	1	5
Gram	0·20	0·50	1·25	0·22	1	2½
Lentils	0·14	0·70	1·00	0·22	1	5
Locust Beans	0·55	0·50	0·70	0·11	1	1
Peas	0·10	0·90	1·00	0·04	1	9
Cereal Grain						
Oats	0·14	0·81	0·55	0·07	1	6
Barley	0·07	0·84	0·57	0·12	1	12
Middlings	0·13	1·50	1·40	0·07	1	11½
Dried Green Crops						
Lucerne meal	2·73	0·78	1·82	0·55	3½	1
Grass meal (very good)	1·20	0·75	2·70	0·80	1½	1

The legume seeds, in general, have a costive influence and it may be necessary to correct this by feeding other laxative foods.

With the exception of sweet lupin seed, lucerne and clover seed (of which small amounts may occasionally be available) the seeds of legumes have low oil contents and their effect on the body fat is consequently good. The fat of animals fed liberally with these seeds is firm and white.

When the mineral composition of the legume seeds is examined it is seen that, though they are slightly richer than the cereals in calcium, they are low and cannot compensate for the poverty of the cereals in this respect, as they do in respect of amino-acids. Moreover, their phosphorus content is about the same. They do not, therefore, diminish the need for adequate mineral supplements. Their vitamin potency is low.

Beans

The field bean (*Vicia faba*) and the imported types, both *Vicia* and *Phaseolus* species, have similar chemical and nutritional characteristics.

New beans do not grind well and as they often cause serious indigestion it is better in every way to use for feeding only beans that have matured for a year. Care should be taken, however, to avoid mouldiness because mouldy beans are dangerous.

Beans are imported from many countries. The red Rangoon or Burma bean contains a small amount of a glucoside which, like that in linseed, produces prussic acid under warm, moist conditions. Far more dangerous, however, is the wild type, known as the *Java* bean (*Phaseolus lunatus*) which, unfortunately, is very like the Rangoon bean in appearance. Specimens should be collected and studied.

Calves crunch whole beans, but for all other animals beans should be kibbled or ground to a meal. Kibbled beans have a way of collecting at the bottom of a mixture of feeding stuffs and if beans are to form part of a mixture they should be ground to as fine a meal as the other ingredients and well mixed. Bean meal does not keep well and it should be stored in a really dry store.

Gram (*Cicer arietinum*)

The feeding properties of this grain are so much like those of beans that it can be used in exactly the same way. It will be seen, by reference to tables of chemical composition, that the protein equivalent is rather lower (15-16 per cent) than that of peas (18 per cent) or beans (19-20 per cent) and the proportions of a mixture may be adjusted accordingly.

Lentils (*Lens esculenta*)

Lentils match beans and peas in their nutritive character and composition. Like peas, beans and gram, lentils are a safe and valuable ingredient in mixtures for all farm livestock.

	Dry Matter	*Crude Protein*	*Oil*	*Carbo-hydrates*	*Fibre*	*Ash*	*Digest. Protein*	*Starch Equiv.*
	per cent	per cent	per cent	per cent	per cent	per cent	per cent	per cent
Bean husk	88·0	3·5	0·2	37·1	42·9	4·3	—	48·5
Lentil husk	88·0	11·1	0·7	47·5	25·6	3·1	1·3	46·7
Pea husk	87·8	5·3	0·7	31·1	47·9	2·8	3·6	64·2

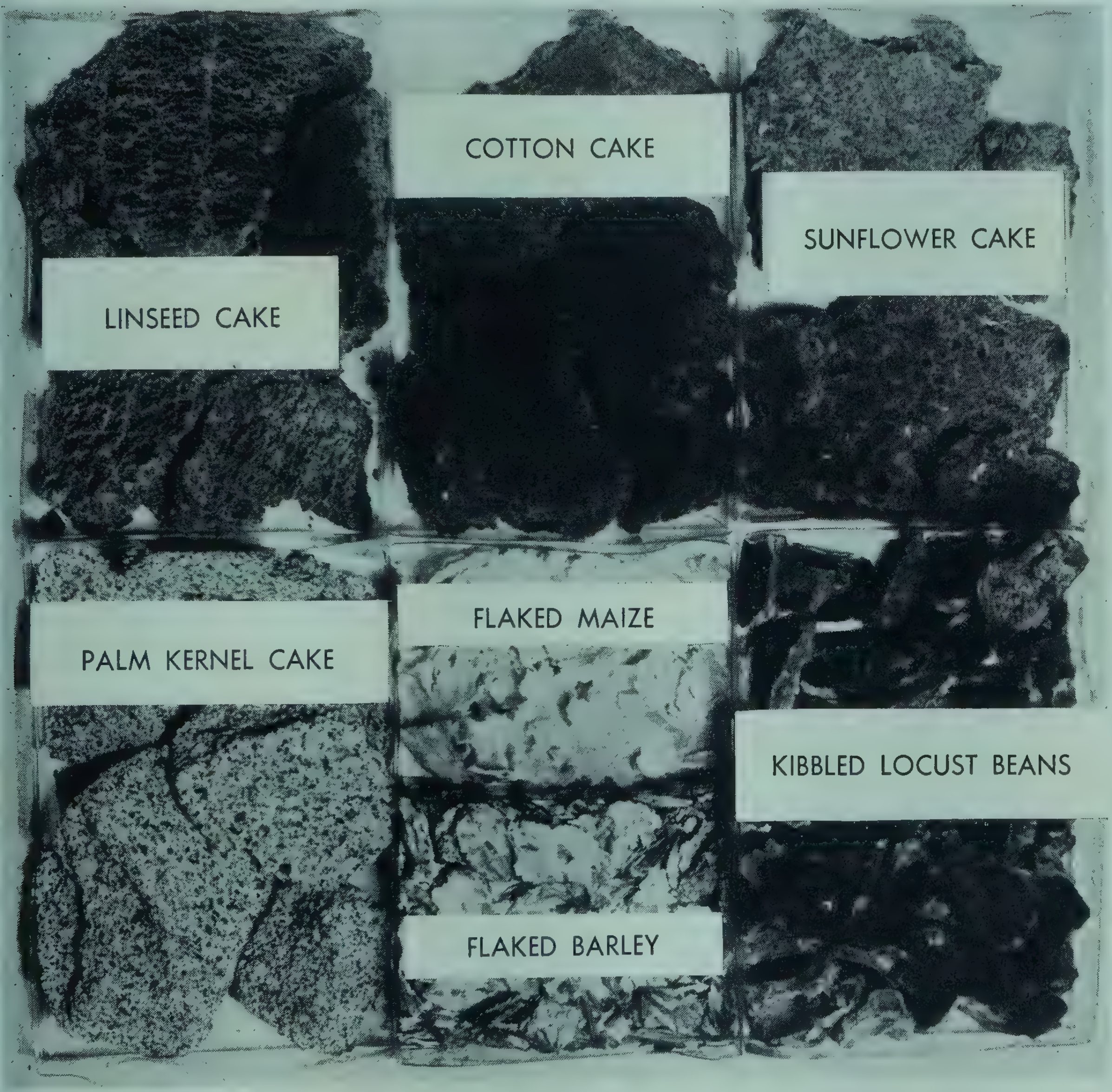

COTTON CAKE
SUNFLOWER CAKE
LINSEED CAKE
FLAKED MAIZE
PALM KERNEL CAKE
KIBBLED LOCUST BEANS
FLAKED BARLEY

FIG. 1.—Various feeding stuffs.

The husks, which are removed when lentils are to be sold for human consumption, are marketed as lentil bran. Woodman gives the figures for the composition of the husks of beans, lentils and peas as shown on previous page.

The figures show that the pea husk has a higher feeding value than either of the others. All are very low in digestible protein but when available in good condition they are useful for lightening a dense, heavy mixture.

LOCUST BEANS, CAROB BEAN (*Ceratonia siliqua*)

The brown, fleshy pods that are imported from the south-eastern Mediterranean countries under the name of locust beans are the sun-dried fruits of the carob tree. Unlike the other leguminous fruits, the part of the greatest feeding value is the pod, the seeds representing only about 10-12 per cent of the whole. The seeds are, moreover, extremely hard and unless they are ground before feeding they are not digested.

The whole bean, pod and seeds, can be ground or the pods may be ground after removal of the seeds. Since the seeds form such a small proportion of the total weight their removal has but little effect on the composition of the meal, which has a starch equivalent of about 70 and contains about 4 per cent of digestible protein.

The peculiar feature of locust beans is their richness in sugar—about 20 per cent. Their sweetness and agreeable taste make them very useful in giving an appetising flavour to other meals with which they are mixed.

They are a safe and wholesome food for all stock and can be included in any proportions provided that the balance of the ration is correctly adjusted. They are apt to go mouldy rather quickly if storage conditions are not good.

LUPIN SEED

The seeds of the varieties of lupin that have been grown as fodder or ‘ green manure ’ contain one or more of the poisonous alkaloids and have therefore been regarded as too dangerous for use as feeding stuffs. It is possible to extract the toxic substance by soaking and steaming, but the process is troublesome and, of course, adds considerably to the cost of the food. A strain of yellow lupin has been bred in which the alkaloid content has been reduced to such a low percentage as to be harmless. This seed is a valuable protein-rich concentrate that can be used with confidence in balanced mixtures for all stock.

PEAS (*Pisum arvense or P. sativum*)

Peas are imported from several countries but, though they differ somewhat in appearance, they do not show any regular differences in feeding value. Amongst the imported peas the black Indian pea should be mentioned because of the frequent occurrence of the poisonous mutter pea (*Lathyrus sativus*) in consignments.

Newly harvested peas, like field beans, are the cause of digestive disturbances and they should not be used until after the end of the year in which they were harvested.

Poultry make good use of whole peas but for all other stock they should be fed as a meal or as split peas. For inclusion in mixtures, meal is preferable because there is then less tendency to separation.

FEEDING STUFFS DERIVED FROM OIL BEARING SEEDS AND NUTS

Vegetable oils are obtained from the seeds and fruits of many species of plants and are used for a great variety of purposes. The residues left after the removal of the oil from most of the species used in commerce are edible and form valuable feeding stuffs for farm animals. The protein content is generally high: the amount of oil remaining depends largely upon the method employed in its removal: the carbohydrates are low—roughly half those of the cereal grains: whilst the percentage of fibre is highest in those in which a fibrous outer coat is left on the nut or seed during the oil removing operations, and so is incorporated in the residue.

The oil is separated from the seed either by pressure or by dissolving in a solvent. Two methods of applying pressure are used, the hydraulic press and the expeller. The older method is the hydraulic press. The seed is finely ground, heated and then wrapped in cloth wrappers, holding about 18 lb. or thereabouts, which are placed in the press.

The oil is not completely removed and the pressed cakes contain amounts varying between 5 per cent and about 12 or 13 per cent, depending on the kind of seed and the operating procedure.

The principle employed in the expeller is to press the seed mass through a tubular cage by means of a worm or screw. The screw is constructed so that the pitch becomes smaller and shallower from the feed end towards the discharge end. The pressure on the seed therefore increases as it travels through the cage and the oil escapes through small apertures in the cage wall. The compressed mass is finally forced out between the sides of the cage and a cone fitted centrally in the discharge end, or through holes in a steel plate, and is cut into suitable lengths by knives as it emerges, giving ‘ expeller flakes ’ and cubes or nuts.

The expeller is slightly more efficient than the press and the oil content of the residue is usually 1-2 per cent lower than in the corresponding pressed cake.

The chemical method of extracting the oil in a solvent, such as petrol, is more thorough than either of the operations that have been outlined above. The seed is ground, to assist penetration of the solvent, and filled into the extraction pots holding from 2 tons upwards. The solvent is pumped in and run off, the process being repeated until the amount of oil remaining in the seed makes further repetition uneconomic. The solvent is recovered by distillation and is used again. Steam is then passed through the extracted meal to remove any traces of the solvent. The meal is dried and, if necessary, ground to the desired fineness. Extracted oil seed meals have between 1 and 3 per cent of oil. Their starch equivalent is therefore lower than that of the cake or expeller flakes of the same kind of seed, their protein content is somewhat higher and they are less palatable. For some purposes, however, the low oil content makes them particularly useful.

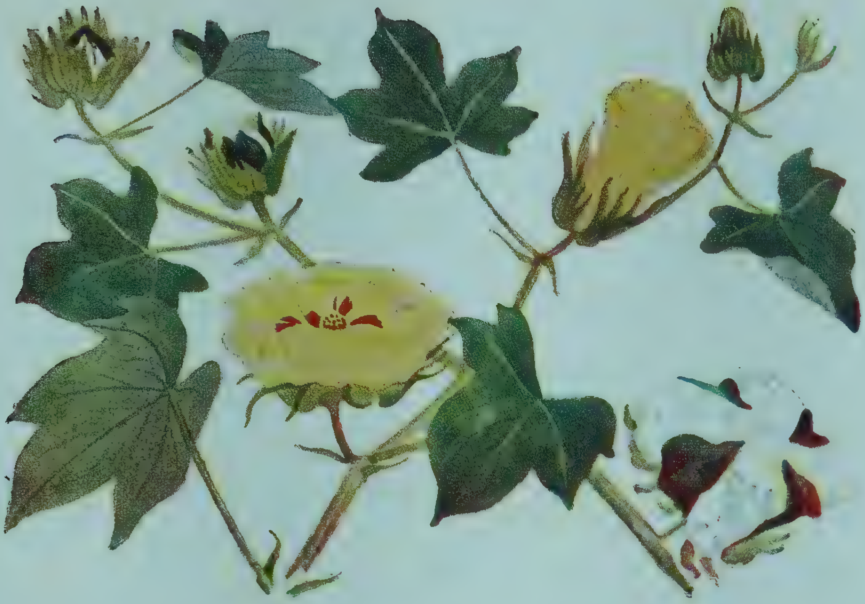


FIG. 2.—The Cotton Plant. Cotton has been cultivated from time immemorial, and many varieties have been developed from the wild species found in the tropical regions of both hemispheres. The plant varies in shape and size, its flowers ranging from red (the sacred cotton tree of India), golden yellow (Egyptian types), to the creamy hue of American Upland. The main producing areas are the United States, India, Pakistan, China, Egypt, the Sudan, and Africa. Though the use of cottonseed oil is mentioned in early Hindu writings, and the Chinese used the oil many centuries ago, it was not until the latter part of the nineteenth century that cottonseed was crushed extensively for its oil, now used as edible oil in margarine and cooking fat; it is also used for soap and many other purposes. The cake is fed to cattle.

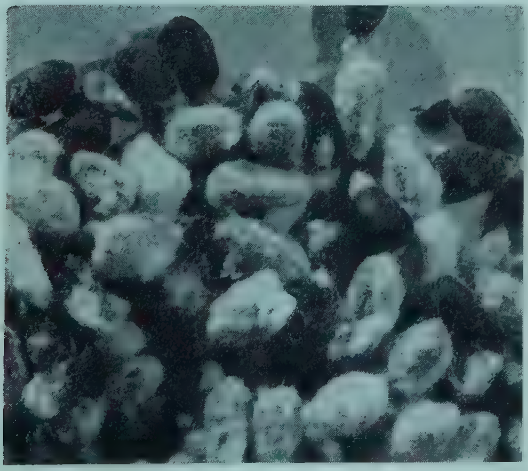


FIG. 3.—Cottonseed: actual size.

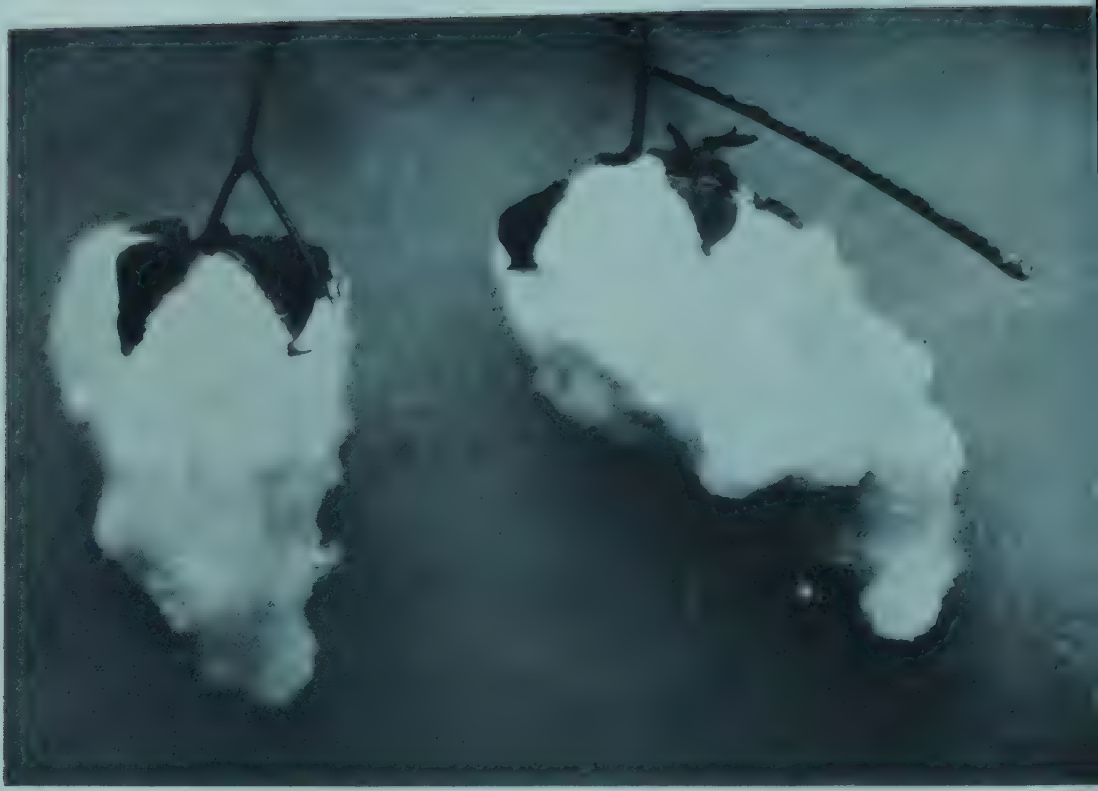


FIG. 4.—Cotton bolls. The egg-shaped seed, which is about the same size as a pea, is hidden under the white lint.

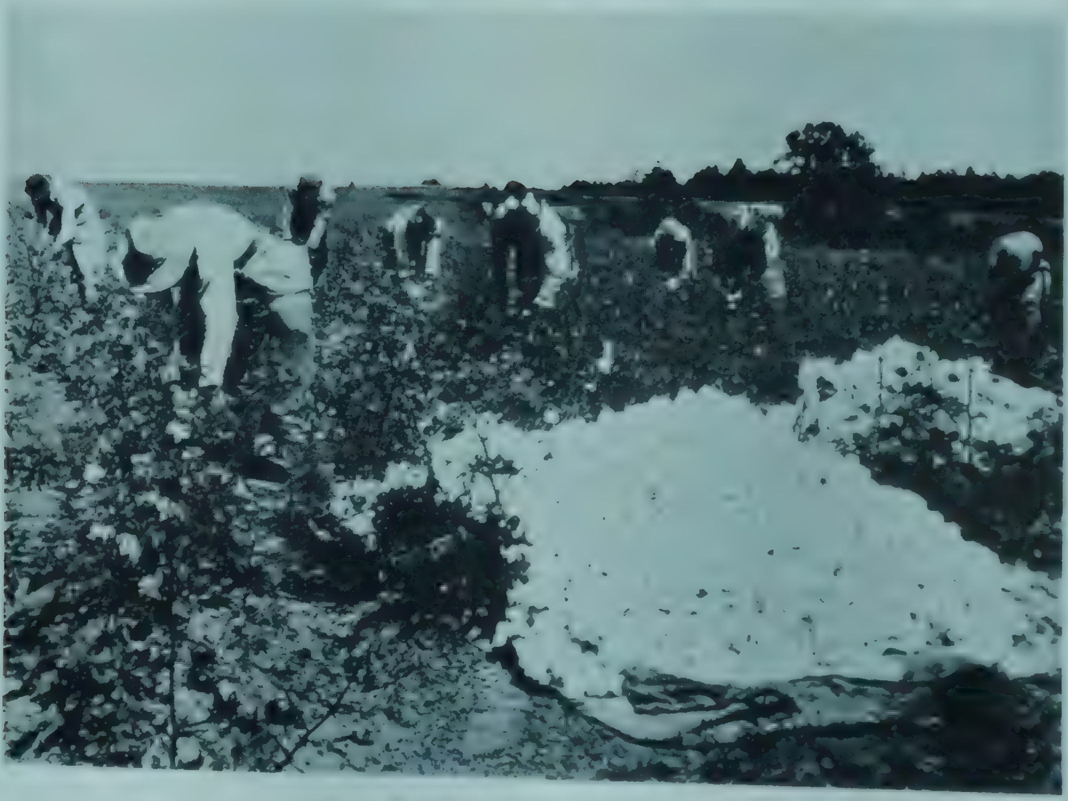


FIG. 5.—Picking cotton by hand.

The pressed cakes are often broken down to a meal before sale and it is important that these meals, containing 5-10 per cent of oil, should not be confused with the meals resulting from the extraction process with oil contents of the order of 1-2 per cent.

DECORTICATION

The seeds of cotton and sunflower are enclosed in a coat that, if included in the cake or meal, adds considerably to the total fibre and lowers the food value. The kernels of groundnut also are encased in a fibrous outer shell. These husks are often removed, the process being known as decortication, and the cake or meal resulting from this treatment is ' decorticated '. Seed crushed without removal of the husk is ' undecorticated '.

Decorticated cakes and meals are of much higher feeding value than the undecorticated; thus, for example:

	Digestible Protein		*Starch Equivalent*	
	Decorticated	Undecorticated	Decorticated	Undecorticated
Cotton cake (Egyptian) . .	35·4	17·8	68·4	41·6
Ground nut cake . . .	42·0	27·7	73·0	56·8
Sunflower cake . . .	33·6	17·2	72·5	49·5

COTTON (*Gossypium hirsutum*)

There are many varieties of the wild cotton plant and the cultivated varieties that have been developed in tropical and sub-tropical regions of the world show many differences. The cotton of commerce is the fibre, or floss, that grows on the outside of the seed husk. The distribution of the fibre on the surface of the husk is not always uniform and two types of seed, known as black seed and white seed, are recognised in the seed-crushing industry. In black seed the fibres grow at either end of the seed and are effectively taken off in the ginning operation. The fibres of white seed cover the whole surface and are much more difficult to remove. Before crushing this type of seed it is subjected to a further operation to detach as much as possible of the adhering short fibre or lint.

The cotton seed oil is contained in the kernel within the husk. The husk or cortex is sometimes separated from the kernel before it is crushed, but more often the whole seed is crushed and the inclusion of the cortex produces a cake that is much higher in fibre and correspondingly lower in protein and oil.

Both types of cake are suitable for cattle and sheep but not for calves, lambs or pigs. Not only is the fibre too indigestible but cotton seed contains a substance, gossypol, which makes even the decorticated cake and meal dangerous to these animals.

The undecorticated cake derived from ' black ' seed is commonly named Egyptian Cotton Cake, whilst that made from ' white ' seed is referred to as Bombay Cotton Cake because the Indian seed is generally of this type.

If the two cakes are compared the lint in the Bombay cake is discernible, particularly if the cake is broken and the fracture examined for the woolly fibres.

The undecorticated cakes have a markedly constipating effect and this rather than their nutritive value determines their use on the farm. They are the common antidote to the scouring effect of young grass and other over-laxative foods, but only for grown cattle and adult sheep.

The decorticated cake, having only about one-third of the fibre of the undecorticated cake, has much less effect on the bowels. It is a high-protein food and must be used moderately: a maximum for dairy cows may be put at 4 lb. daily. The protein quality is not good, so that cotton seed should not be relied upon as the main source of protein and 2-3 lb. of the decorticated cake or meal is probably as much as is efficiently used in most rations. The calcium content is low.

The so-called semi-decorticated cake is, as its description implies, intermediate in character, having about 11 per cent of fibre, 11 per cent of oil and 35 per cent of crude protein.

COCONUT (*Cocos nucifera*)

The fruit of the coconut palm is a familiar object in fruiterers' shops. It consists of a hard shell covered by a fibrous outer coat or coir and containing the edible kernel. At first the content of the nuts is fluid and the pulp forms on the inside of the shell as ripening proceeds. When the ripe nuts are gathered they are split open, the ' milk ' is run off and the nuts are allowed to dry for a day or two to facilitate the removal of the kernel. This material is dried in the sun or in kilns, and is then the copra of commerce. At this stage it contains about 66 per cent of oil, which is reduced to about 8 per cent in the coconut cake and rather less in the coconut meal (1). The oil has been said to cause a tallowy condition in butter when too much of the cake has been given to cows. On the other hand, the fat of pigs receiving coconut cake has been firm and of good flavour. About 3 lb. per day appears to be the safe limit for milking cows if butter is being made. Fattening pigs can have 20 per cent of their ration in the form of coconut meal, and cattle fattening mixtures may safely include as much as 40 per cent. It has been used very successfully in the feeding of sows, ewes and calves.

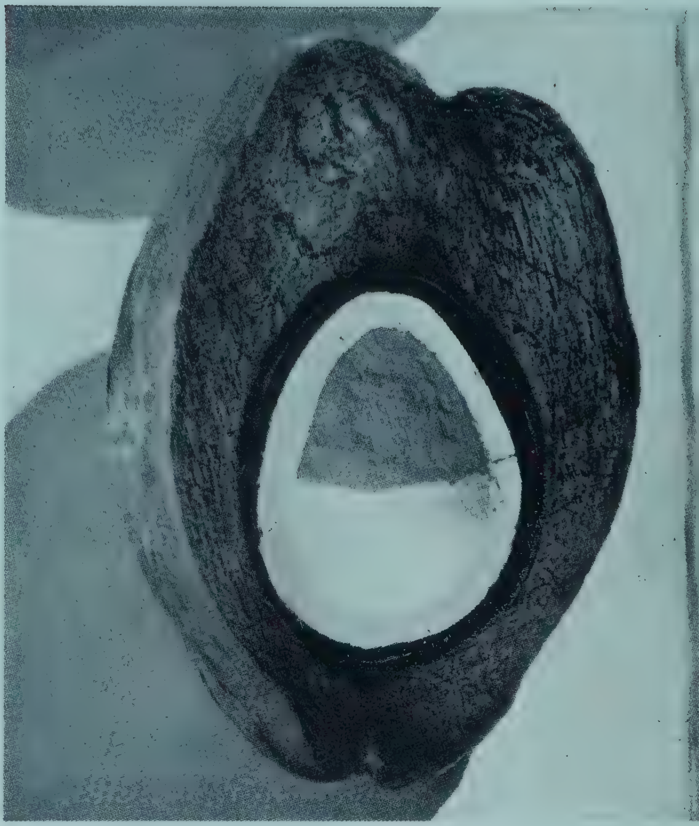
The points requiring attention are:

(i) Though coconut is readily taken when animals have been accustomed to it, it must be introduced gradually.
(ii) It swells very much when moistened and if it is being fed in large amounts it is better to soak it before feeding.
(iii) It does not keep well. Dry storage is very important. Rancid cake causes digestive disturbances and diarrhoea.

GROUND-NUT (*Arachis hypogoea*) (earth-nut, monkey-nut, pea-nut)

This is a leguminous species that has an unusual way of developing its seed. After fertilisation the flowering heads turn down into the ground and the fruit matures below the surface of the soil. The fruit is a pod, enclosing up to five kernels which, when ripe, contain 48-50 per cent of oil. The nuts are generally decorticated before being shipped because the cubic space occupied by the undecorticated whole nuts is almost double that required by the same weight of decorticated nuts. A partial removal of the shell produces a cake that is described as semi-decorticated, but this description must not be assumed to imply that half the shell has been removed. The

FIG. 6.—Coconut (*Cocos nucifera*). The origin of the coconut is unknown, but it is thought to have spread eastwards across Polynesia from the Indian Ocean. It flourishes on the coasts of all tropical countries and is extensively cultivated, the main producing areas being Indonesia, the Philippines, Malaya and Ceylon. The outer fibres of coconuts are impervious to salt water, and because of this the fruits which dropped from trees growing on the shore were spread by tides and currents throughout the whole of the innumerable South Sea Islands. The coconut palm is one of the most important sources of food and raw material for the people who live in the tropical regions. The hard shell is burned for charcoal, and the coir is a valuable raw material for the making of ropes, mats, mattresses and a host of similar articles in daily use. Copra, the dried kernel of the coconut, yields oil used in the manufacture of, among many other products, margarine and chocolate and soap and cosmetics. The cake provides animal feeding stuffs.



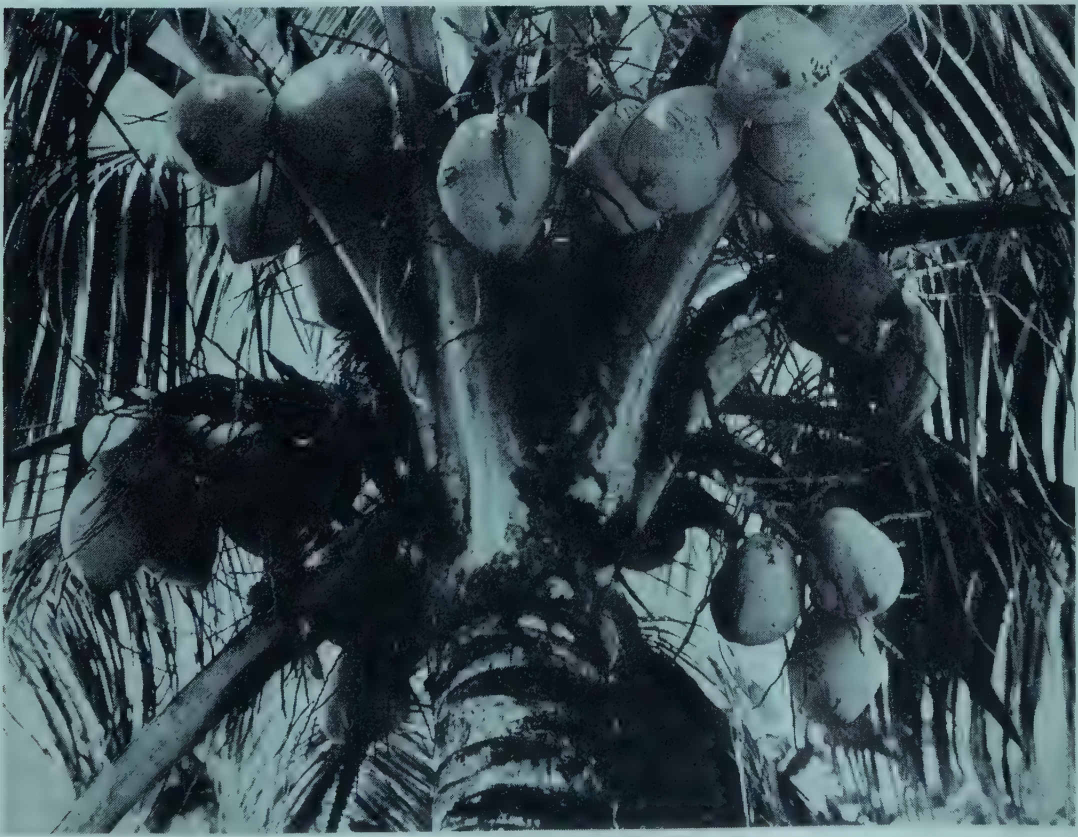


FIG. 7.—Coconuts on a tree. The two dark nuts on the right are mature and will ultimately fall to the ground where they will be collected by the coconut cutters. One tree may have as many as sixty to eighty nuts in various stages of development.

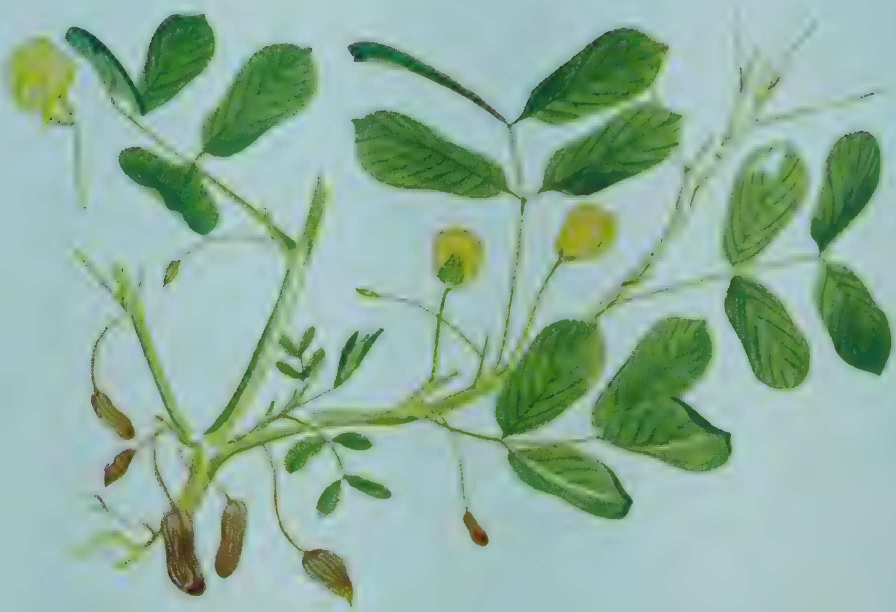


FIG. 8.—Ground-nut plant (*Arachis hypogaea*). Ground-nut, also known as pea-nut, monkey-nut and arachis-nut. Native of South America and West Indies; now cultivated in most tropical and subtropical countries. Slave traders, using it as food for captives on the South Atlantic voyage, introduced it into West Africa early in the sixteenth century. Magellan, on his first expedition round the world in 1519, took ground-nuts from Peru to the Moluccas and Philippines, whence they were carried to Japan, Indo-China and Southern Asia. Spaniards took them to Mexico and Spain. Ground-nut is a true legume (rather than a nut). Pods are produced from small, inconspicuous flowers an inch or two above ground; after fertilization flower bends downwards, rapid growth of podstalk carries it into ground, where it grows to maturity.

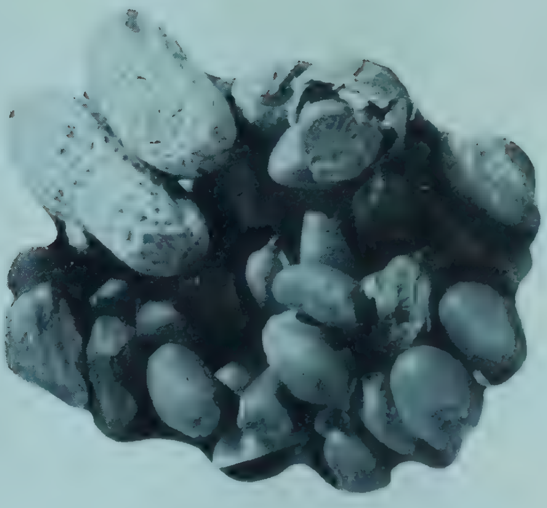


FIG. 9.—Ground-nuts: actual size.

proportion is not fixed; it varies considerably and the only safe guide is a laboratory determination of the percentage of fibre in the cake or meal.

Some undecorticated ground-nut cake or meal comes on to the market. It is equal to linseed cake in protein and oil but contains about two and a half times as much crude fibre which, moreover, is of much lower digestibility. It has, therefore, all the disadvantages of the high-fibre feeding stuffs for young animals, pigs and poultry, and even for milking cows at a high level of production. When undecorticated ground-nuts are crushed, the large amount of shell or husk obstructs the removal of the oil and the resultant cake may contain as much as 9 per cent, or even more, of oil. To prevent this loss the oil is often extracted by the solvent process, by which a meal is produced containing only 2 per cent of oil. The effects on the nutritive value of these different methods of treatment are evident when the analyses are compared :

	Crude Protein per cent	*Oil* per cent	*Crude Fibre* per cent	*Starch Equivalent* per cent
Ground-nut cake				
decorticated . . .	47	7½	6½	73
undecorticated . . .	30	9	23	57
Ground-nut meal				
decorticated . . .	54	½	5½	70
undecorticated . . .	32	2	25	44

The decorticated cake and meal are safe foods for all farm livestock in properly balanced rations. The protein is of good biological value and is not markedly low in any of the essential amino-acids. It supplements the amino-acids of the cereals effectively. Ground-nuts are low in calcium and in vitamin potency except vitamin B, in which the oil seeds and cakes are moderately rich. The oil in the pressed cake or expeller flakes may cause softness of fat in bacon pigs, and for this reason the extracted decorticated meal is preferred for pig feeding.

The high fibre content of undecorticated extracted ground-nut meal makes it almost as useful as undecorticated cotton cake as a corrective for cattle on spring grass. The high oil content of the pressed cake largely neutralises the binding effect of the fibre.

In foreign-made ground-nut cakes and meals castor-oil bean is sometimes present. It is rarely found in the product of British oil mills.

HEMP (*Cannabis sativa*)

Hemp is grown chiefly for its fibre for ropes and various other uses. The seed, which contains about 33 per cent of oil and about 15 per cent of fibre, is used in the countries in which it is grown for feeding to cattle and poultry. It is, therefore, not often seen in this country but hemp seed cake or the extracted meal may occasionally come on the market. Although the protein content is almost equal to that of linseed cake, the high percentage of indigestible fibre brings it down to the level of the undecorticated cotton and ground-nut cakes and meals. It is suitable only for feeding to working horses (up to 3 lb. per day), fattening cattle (up to 5-6 lb. per day) and adult sheep (1 lb. per day). It can be included in compound cakes and meals within the limits set by its large fibre content, the low digestibility of which must be taken into account.

KAPOK (*Ceiba pentandra*)

The seeds of the kapok tree are valued for the ' floss ' with which they are covered. The cake or meal is similar to the hemp seed products in composition and feeding value. Like them, it contains a high percentage of indigestible fibre.

LINSEED (*Linum usitatissimum*)

This is the seed of the flax plant, many varieties of which are in cultivation. Different varieties have been developed for growing the flax fibre for linen and the seed for linseed oil. In the past the principal sources of linseed have been the Argentine, U.S.A., India, Egypt and Russia and, as might be expected, there is some variation in the composition of the cakes and meals that come on to the market.

The seed of linseed is used to a limited extent in the feeding of young calves and sick animals and poultry during the moult, and also for chicks that are backward in feathering. The seed is too hard to feed whole and must either be crushed or softened by soaking or boiling. If linseed is wetted before being fed, care must be exercised to prevent the development of prussic acid, an extremely dangerous poison, to which calves succumb particularly easily. The acid is formed by the action of an enzyme from a substance named *lina-marin* when the necessary moisture and temperatures are provided. The enzyme is destroyed if sufficient heat is applied and ten minutes boiling is all that is necessary. From the point of view of the maker of calf meals or any prepared mixture that might be soaked on the farm before feeding, it is important, if linseed or its products are included, that the purchaser should be warned.

Linseed cake is manufactured here and is imported from several foreign countries. The foreign made cakes tend to be slightly richer in protein and in oil.

Linseed cake is frequently ground to a meal. Since this meal contains all the oil of the cake it must not be confused with extracted linseed meal. The term linseed meal is also applied to the meal produced by milling the entire seed. Thus, linseed meal may imply three quite distinct materials of the following approximate composition :

	Dry Matter	*Crude Protein*	*Oil*	*Fibre*	*Starch Equivalent*	*Protein Equivalent*
Linseed meal from entire seed	93	24	36	6	119	18½
Linseed meal from linseed cake	89	30	9½	8½	74	24½
Linseed meal (extracted)	88	36	3	9	64	30½

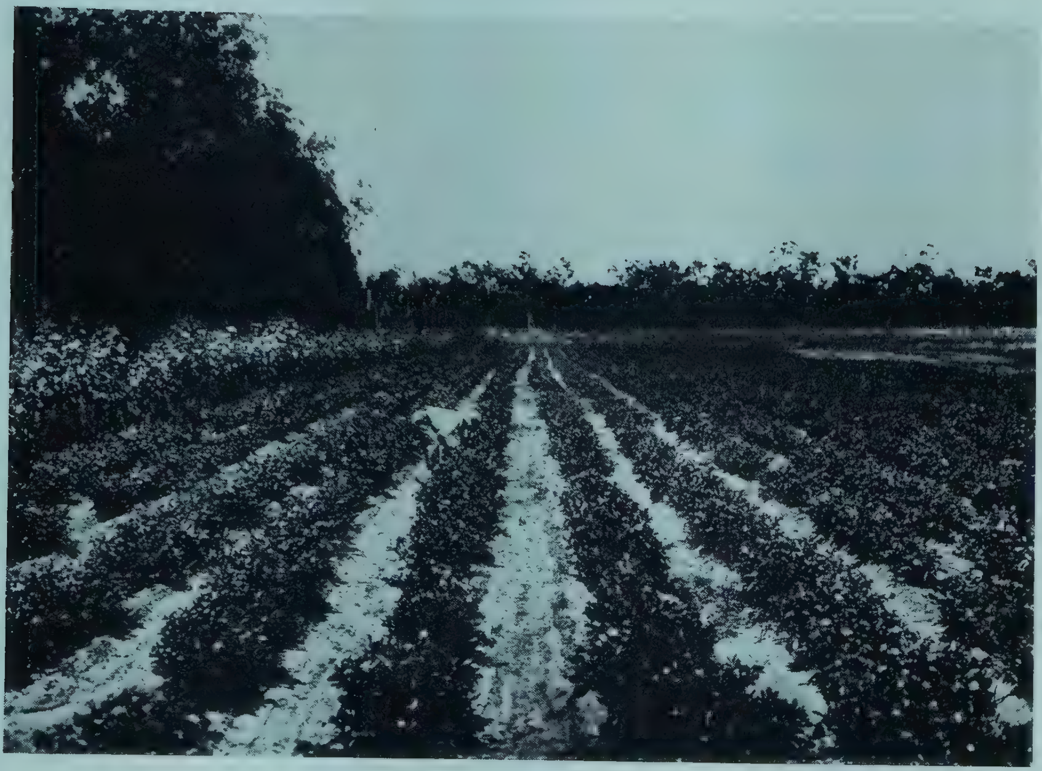


FIG. 10.—Cultivation of ground-nuts in rows.

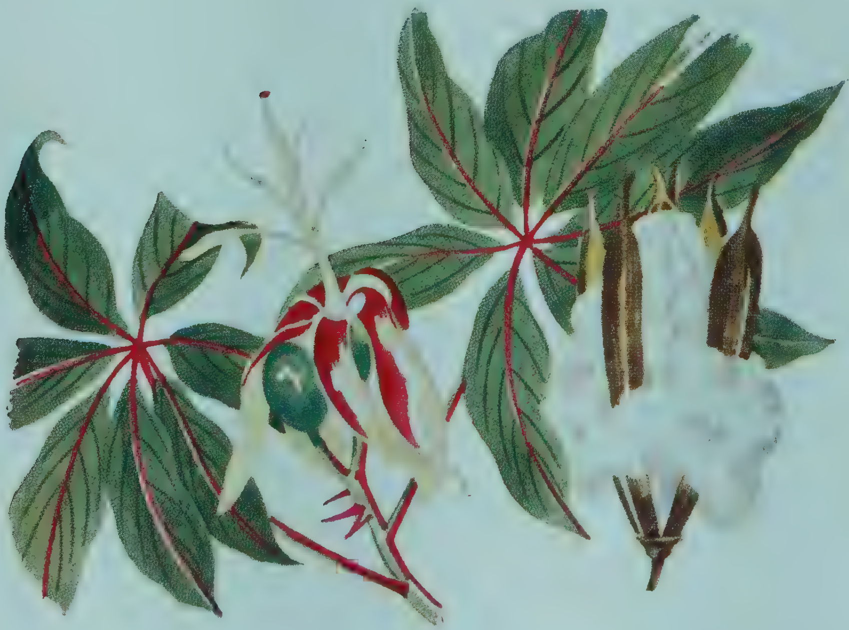


FIG. 11.—The Kapok tree. Kapok (*Eriodendron anfractuosum*) is a tree of Bombacaceae family. Native of tropical America. Cultivated in Java and less extensively in Philippines, Malaya, Africa, Ceylon, India and South America for the production of down which, being impervious to water, is used in life-jackets and rafts. Seeds yield oil of pleasant odour and taste used in edible products and soap.

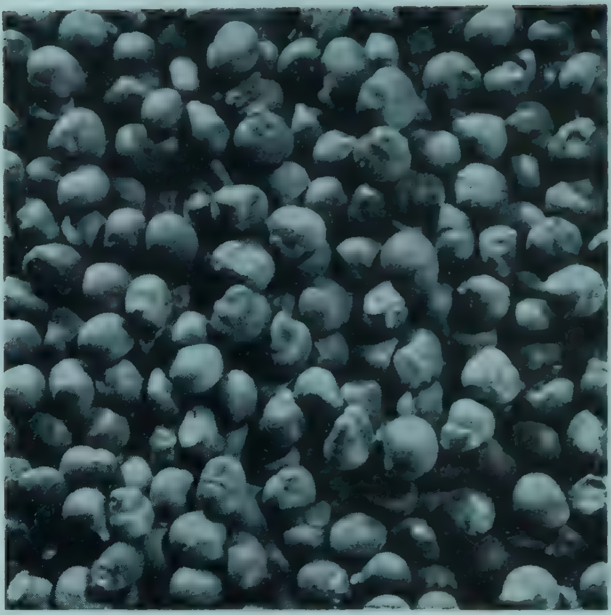


FIG. 12.—Kapok seeds: actual size.

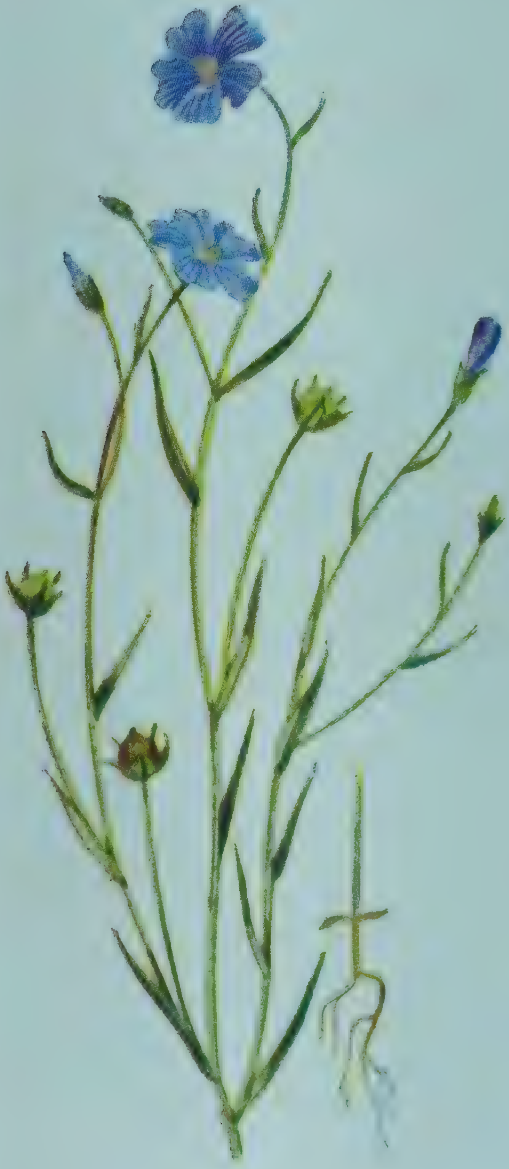


FIG. 13.—Flax Plant (*Linum usitatissimum*). Linseed is the seed of the flax plant. A native of Central Asia, it is now cultivated throughout the temperate zones. Originally grown for the production of fibre. Introduced into the Argentine, now the biggest producer, after 1850. Seeds yield a drying oil much used in oil paints and varnishes, printing and lithographic inks, linoleum and oilcloth. Also used in soft soap, and a valuable animal feeding stuff is made from the cake.

As compared with the cereals, linseed is rich in calcium and in phosphorus but in the amounts fed these percentages do not make a very substantial contribution to the total intake :

	CaO per cent	P_2O_5 per cent
Linseed	0·3	1·4
Linseed cake	0·5	1·8
Beans	0·2	1·2
Oats	0·14	0·85

Linseed cake has a reputation for producing a ‘ bloom ’ on the coats of animals, the credit being given to the oil. The cake, in sufficient amounts, is laxative in its effect, and, in excess, it exerts an undesirably softening influence on the butterfat of milk used in butter making. This softening property of the oil makes linseed cake unsatisfactory as a regular ingredient in the rations of fattening pigs, but in cases in which a laxative is required a little linseed cake or the ground or boiled seed is used with success. The warning against soaking linseed before feeding may be repeated here. The extracted meal, of course, is not likely to have any softening effect and, if prices make it economical, it can be used in moderation in mixtures for pigs without injury to carcase quality.

Apart from the special circumstances just mentioned, linseed cake can be included in mixtures for all classes of livestock.

NIGER (*Guizotia Abyssinica*)

This is a small, black seed grown in tropical Africa. Small quantities are crushed. The cake, which is also black, is comparable with undecorticated ground-nut cake in feeding value and is useful for inclusion in a ration in which its rather high fibre content, about 18 per cent, is not a disadvantage.

PALM KERNEL (*Elaeis guineensis*)

The fruit of the palm tree yields two kinds of oil. ***Palm oil*** is obtained from the fleshy, pulpy pericarp which covers the hard, black shell of the palm nut, and palm kernel oil from the white kernel of the nut. Palm kernel cake or meal is the residue of these kernels after the oil has been removed. The pressure and the solvent extraction methods are used, the pressure methods leaving a cake containing about 6-8 per cent of oil, while the extracted meal contains 2 per cent or even less. Some palm kernel cake is imported from the countries where the fruit is grown. These imported cakes usually show higher percentages of oil and fibre than English made cakes. As with other oil seed residues, the differences between expressed and extracted meals must be taken into account. The earlier unpopularity of palm kernel cake may have been the result of inferior manufacturing techniques and poor keeping quality, or perhaps from unskilful feeding management on the farms. A sudden change from linseed cake to palm kernel cake, for instance, would certainly cause animals to refuse it. Palm kernel cake, even with a comparatively high oil content, is dry and gritty and is never a really palatable feeding stuff. It is, however, a safe and wholesome material, and if reasonable care is taken in the arrangement of the feeding it is eaten readily.

As an ingredient in mixed feeds and compounds its lack of palatability is of less importance. The protein ratio (17 per cent protein equivalent: 73 per cent starch equivalent) is approximately correct for milk production, and the cake can therefore be incorporated in any convenient proportion in milk production compounds.

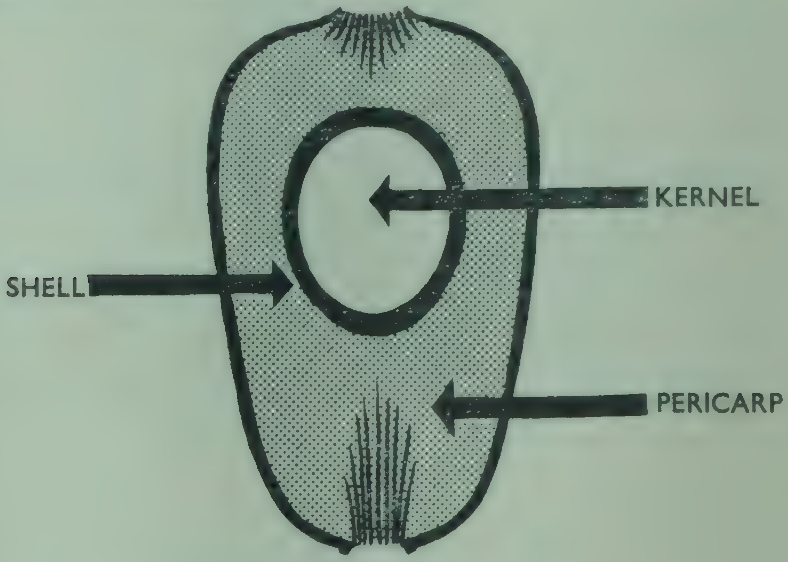


FIG. 14.—Cross-section of a palm fruit.

Fed in mixtures of feeding stuffs, palm kernel cake, or the extracted meal, has been found satisfactory in amounts up to 6 lb. per day for grown cattle and proportionately less for younger animals. Its effect on the butterfat of milk is beneficial rather than harmful.

Young pigs do not always take to it and it must always be introduced in pig feeding very gradually. It is useful in mixtures for sows and all pigs over the 100 lb. live-weight stage. Even for these classes about 25 per cent of the mixture in the form of palm kernel cake or meal must be regarded as the maximum. In such quantities it is readily eaten and the oil does not produce softness in the fat of baconers.

Neither the cake meal nor the extracted meal are popular with poultrymen, but up to 20 per cent has been fed successfully in poultry mashes (Halnan).

RAPE, COLE, COLESEED (*Brassica napus*)

The cake obtained from the rape seed is not popular on British farms because of its bitter, rather unpleasant taste and the frequent contamination with mustard seed. Mustard seed is not poisonous in the ordinary sense, but the oil of mustard may be harmful and may make animals refuse the food. Mustard oil is, however, volatile, and if the cake is steamed the mustard oil is driven off. Where this operation can be carried out, rape seed can become a useful component of compounds for grown cattle and sheep. It should not be included in mixtures for young stock.

SAFFLOWER OR KURDEE (*Carthamus tinctorius*)

There is little experimental information available on the feeding value and characteristics of the cake made from safflower. Undecorticated cakes are

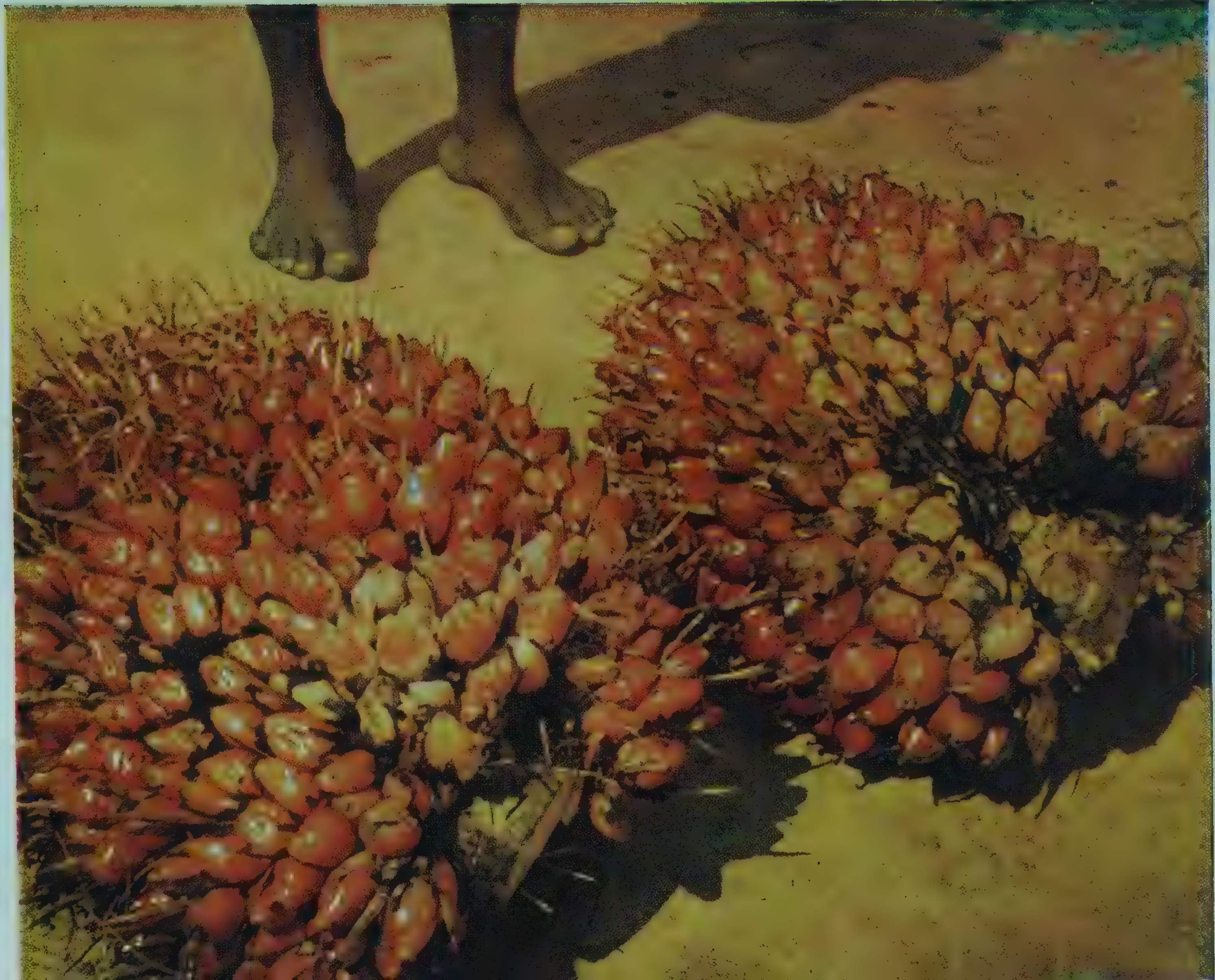


FIG. 14A. — The Palm. Palm oil is extracted from the fleshy part of the fruit of the palm (*Elaeis guineesis*), a native of tropical West Africa and now extensively cultivated in Africa, Indonesia and Malaya. The Portuguese reported, as early as 1470, that it was used by the negro population for cooking. The first recorded export in an English ship was in 1588, when Captain Welsh brought home thirty-two barrels from Benin. The earliest recorded shipment of any size to England was 150 tons landed in 1806 at Liverpool. Palm plants were brought to Indonesia in 1848 from Mauritius, and it is reported that the proposal to establish experimental plantations met with objections from Government officials, who thought it a waste of time to cultivate a palm tree of which nothing was known in places where the coconut palm had constituted the traditional crop for centuries. Palm plants were first introduced into Malaya in 1875.

occasionally offered. The undecorticated cake has a very high percentage of fibre, around 33 per cent, which limits its use severely. In the decorticated cake the fibre is reduced to about 6 per cent and the crude protein reaches the high figure of 47-48 per cent: the decorticated cake is therefore a useful source of protein in compounds.

SESAME (*Sesamum indicum*)

Sesame, or ' Gingelly ', cake is a valuable, high-protein food, combining the high protein of decorticated ground-nut cake with some of the mildly laxative properties of linseed cake. The cake crushed in France has usually a much higher fibre content—about 17 per cent—and a correspondingly lower content of protein and a lower starch equivalent, than the English product.

SOYA BEAN (*Soya hispida. Glycine Max*)

Soya bean cake or meal is one of the most valuable sources of vegetable protein, the chemical composition being comparable with that of milk protein. It has been used with success to replace animal proteins in feeding pigs and poultry; it is essential in such circumstances to ensure an adequate supply of those mineral elements that are not present in the soya bean. A comparison of the minerals in soya bean meal, oats, fish meal and dried milk powder brings out the importance of this—the figures are taken from *Scientific Principles of Poultry Feeding* by Halnan:

MINERALS PRESENT AS PERCENTAGES OF FEEDING STUFFS (2)

	Sodium Na	*Chlorine Cl*	*Calcium Ca*	*Phosphorus P*	*Magnesium Mg*
Soya bean meal	trace	0·07	0·21	1·00	0·223
Oats	0·168	0·07	0·102	0·395	0·130
Fish meal	0·40	0·60	7·50	2·75	?
Dried milk	0·51	1·21	1·32	0·886	0·140

As compared with the two animal products, soya bean meal is very short of sodium and chlorine and also of calcium. Its phosphorus content is appreciably higher than that of the cereals, as represented by oats, and is fully equal to that of dried milk. When soya bean cake or meal forms a major part of the food protein of growing or breeding stock, it is therefore very important that these deficiencies of minerals should be made good; common salt, ground limestone or chalk, with some steamed bone flour, being the obvious materials to use.

Soya cake and meal are low in fibre and about three-quarters of the crude fibre is digestible. The cake is distinctly laxative and for this reason is very useful for mixing with feeding stuffs that, by reason of high fibre or other causes, are too binding.

Fed with other foods to give a suitable nutritive balance, soya bean cake or meal is a safe and excellent food for all classes of farm animals.

Sunflower (*Helianthus annus*)

Although the percentage of fibre in sunflower seed is as high as 28, the seed is fed with success to laying hens in place of some cereal grain. The seed contains about 32 per cent of oil, giving it a high energy value (starch equivalent, 103). The oil is said to be particularly useful during the winter and when the birds are moulting.

Undecorticated and decorticated cakes are made. The high fibre (30 per cent) of the undecorticated cake, and the still higher fibre (35 per cent) of the undecorticated, extracted meal, restricts their use to the feeding of adult cattle.

The decorticated cake is a very useful high-protein food of good digestibility and can be freely used in balanced mixtures for all livestock. The high oil content (13-14 per cent) is useful in mixtures that are unduly low in this constituent.

The sunflower cakes are very hard and are best fed ground to a meal and incorporated in compounds.

Castor Bean (*Ricinus communis*)

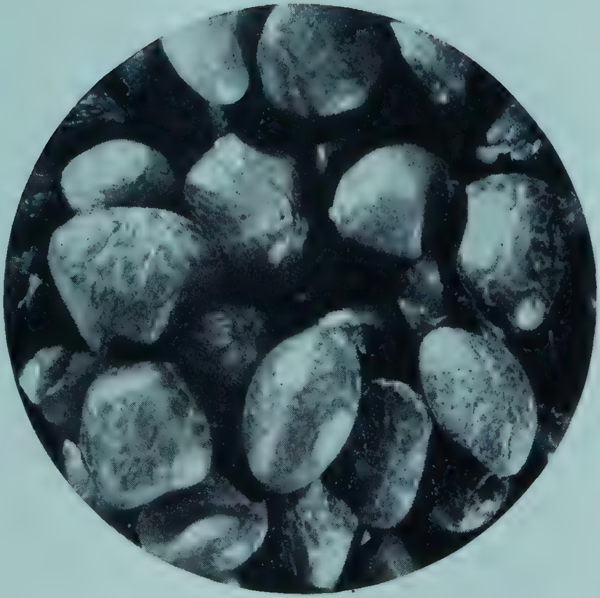
Castor beans are crushed and the oil is extracted by the solvent method to obtain castor oil. The residue, castor bean meal, contains a substance, ricin, which is a very dangerous poison to all livestock and renders it unfit for use as a feeding stuff. The poisonous property can be destroyed by heat treatment and a 'detoxicated castor bean meal' is manufactured. It contains a very high proportion of indigestible fibre, has a starch equivalent of under 25 per cent and its digestible protein is only about 23 per cent, so that it is, at the best, a low grade feeding material.

Castor bean appears as a contaminant in other oil-seed cakes that have been processed in the same mill after castor beans. Only very thorough cleaning of the whole processing plant can prevent contamination, and in many imported oil-cakes, particularly those manufactured in the Argentine, castor bean husk can be detected. Unfortunately, the distribution of the impurity is not at all uniform throughout. The first seeds to go through the crushing machinery after castor beans will carry with them the greater part of the castor beans left in the machines, and as the flow of seed continues the degree of contamination will decrease. The presence of any traces of castor bean should throw suspicion on the whole consignment, which should be sampled with extra care and, even though the samples show no more than a low degree of contamination, the consignment should be kept for use in compounds for adult cattle only and should be well 'diluted' by including it at the rate of not more than, say, 5-10 per cent.

Poppy (*Papaver sp.*)

Poppy seed cake is not often available. It has a useful content of digestible protein (27-29 per cent) and a starch equivalent of 62. The risk of opium being present in sufficient amount to be harmful, however, makes it an unsafe food. If used at all, it is best combined in small proportions with other materials and restricted to mixtures for fattening cattle.

FIG. 15.—Palm Kernels. The palm kernel lies at the centre of the palm fruit. It yields an oil widely different from that extracted from the fleshy pericarp which surrounds it and resembling coconut oil in its constituents, properties and application. Palm kernels were first exported in 1850, but their value was not appreciated for at least ten years afterwards.



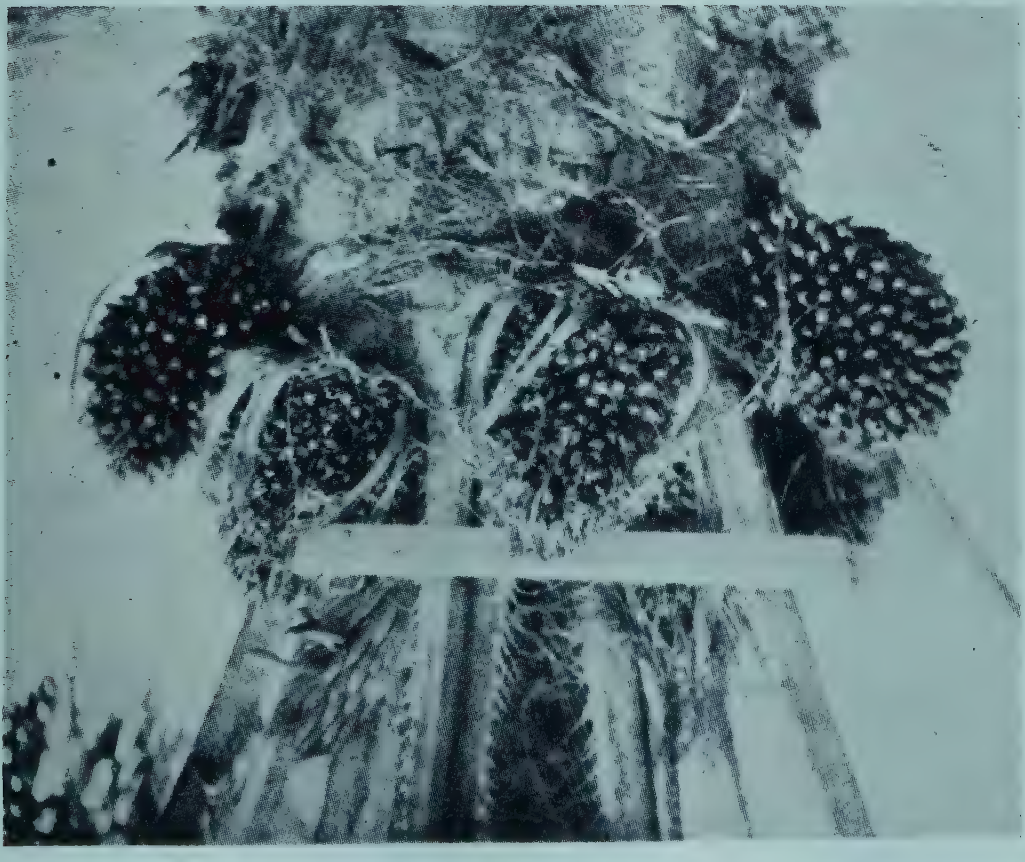


FIG. 16.—Fruits of the oil palm on the tree.

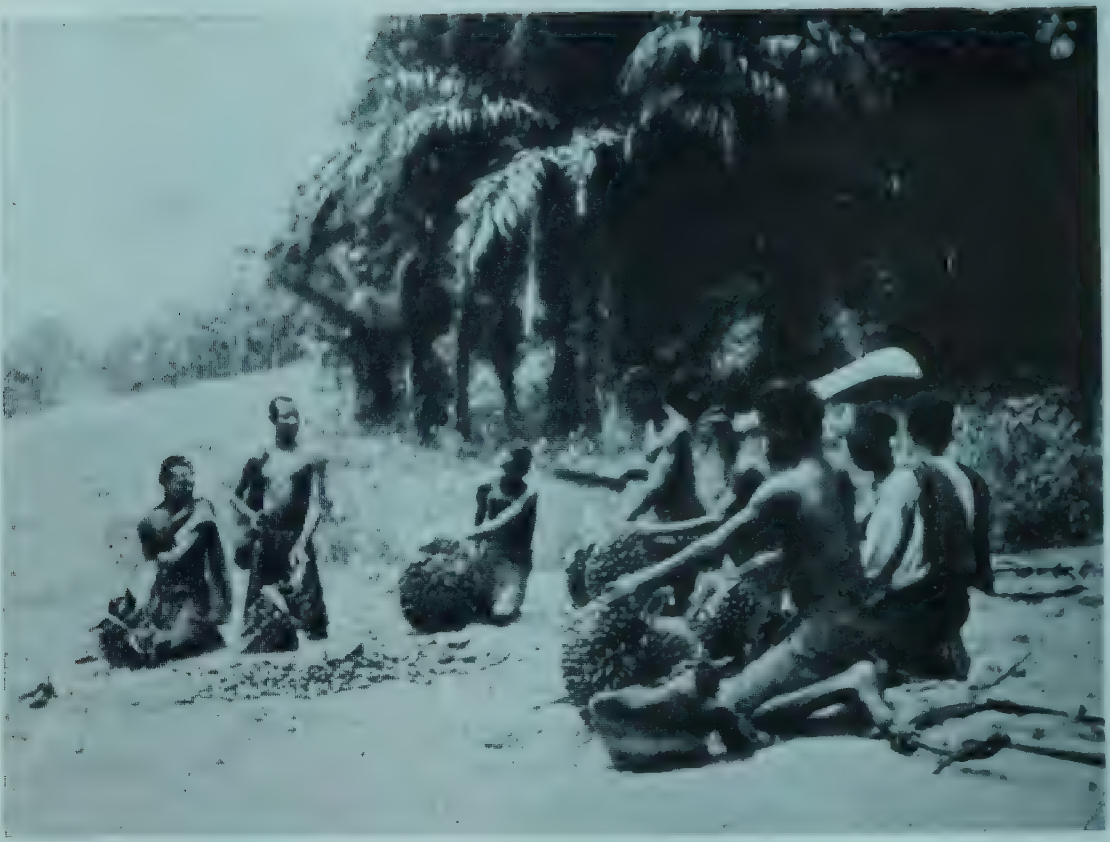


FIG. 17.—Separating the fruits of the oil palm.

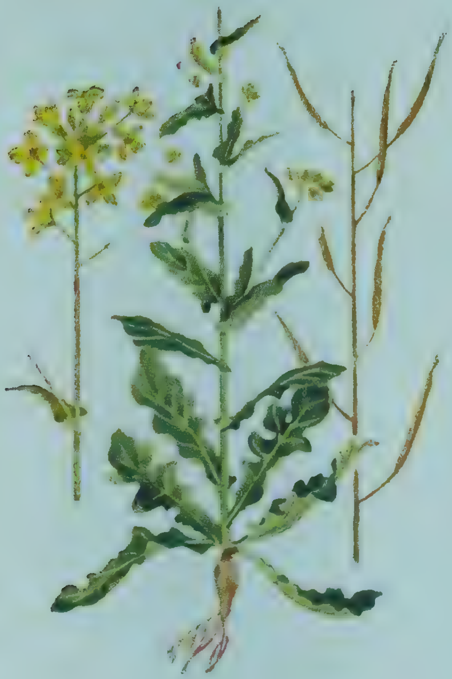


FIG. 18.—Rapeseed (*Brassica napus*). This seed yields 35 per cent. to 40 per cent. of oil. It is grown in China in great quantities and, to a lesser extent, in India. Production in European countries is not high.

MOWRAH (*Bassia latifolia*)

There is little recorded experience of the use of the meal derived from this seed as a feeding stuff. The extracted meal is used for killing worms on golf greens and, in view of its poisonous properties, it should not be included in mixtures for livestock.

SHEA NUT (*Butyrospermum Parkii*) is closely related but is darker in colour and has a very bitter taste. It is not poisonous but is so unpalatable that it is not suitable for feeding.

FEEDING STUFFS OF ANIMAL ORIGIN

The feeding stuffs of animal origin are valued particularly for the high quality of their proteins. Some materials, e.g. milk, fish meal and meat meals containing a good proportion of bone, provide also minerals in proportions that are well suited to the animal's needs. Certain of the animal products are rich sources of some vitamins, particularly of the B group.

The nutritional value of animal proteins is high because they almost all contain all the necessary amino-acids. Animal proteins are not all identical in composition; milk proteins and muscle proteins, for example, differ in some degree, whilst gelatin, though a pure animal protein, is short of tryptophane, one of the ' essential ' amino-acids, as well as tyrosine and cystine.

Some twenty or more amino-acids are found in animal proteins. Many can be synthesised by the animal from elements in the food, but there are ten which, it appears, must be supplied in the form of amino-acids, for which reason they are termed ' essential '. Those amino-acids that need not be supplied ready-made are described as ' non-essential '. All animals, however, are not alike in this respect and the classification into essential and non-essential groups is not absolute. For example, cystine has been found in laboratory investigations to be ' non-essential ' to rats but it should probably be placed in the ' essential ' group for farm animals. Again, ruminants are better equipped than non-ruminants for building up proteins approaching animal proteins in composition from the body substance of the great bacterial population of the rumen. These bacteria subsequently reach the stomach and are digested, yielding amino-acids that, in turn, are combined into the body proteins of the animal.

Other causes of differences in amino-acid requirements of animals are differences in age and type of production. It is clear that no single ' ideal ' combination of amino-acids can be looked for and, in practice, the complication of differing, and changing, needs of animals and the variable composition of the food materials, make exact calculations impracticable. The best that can be done is to see that the diet of any particular class of livestock is well provided with such amino-acids as are known to be important and to rely upon the amino-acids from a variety of foods to supplement each other adequately. The important amino-acids for farm animals are lysine, tryptophane, histidine, arginine and cystine, whilst for chicks arginine, tryptophane, histidine, methionine and glycine are necessary.

Since the use of feeding stuffs of animal origin is so largely concerned with the provision of protein, a few more general observations on proteins may usefully be made here.

A *large* excess of protein above the optimum should be avoided both because it is financially uneconomic and because it may result in a form of indigestion and scouring. Attempts to force the rate of muscle (i.e. lean meat) development and growth rate of pigs by feeding excessively high protein diets have shown that no advantage can be gained by exceeding the optimum quantity.

Insufficient protein, on the other hand, is a direct cause of loss. Growth and production are checked, less growth or production is obtained per lb. of food consumed and all overhead costs are increased through the lower output per unit of time. It has also been shown by Hammond at Cambridge that undernourishment of the young, growing animal, permanently and adversely affects the body conformation so that the finished, fat animal shows a proportionately poorer development of the more valuable ' meaty ' joints of the carcase and a greater proportion of the inferior parts.

Protein deficiency can result from inadequacy of total protein or from lack of ' essential ' amino-acids, and the special value of animal protein foods can be attributed mainly to the insurance that they provide against serious amino-acid deficiencies. The standards of protein requirements that have been generally accepted make allowance for unbalanced proportions of amino-acids. The more nearly the proportions in the diet approach the needs of the animal, the more efficient the protein as a whole becomes. Some foods are known to be particularly efficient sources of protein and when they are included in amounts sufficient to provide most of the animals' protein requirements, the standard figures for protein are probably higher than is really necessary. Such foods are young grass, dried or fresh, milk, whole or separated, fish meal, dried blood meal (if not subjected to excessive heating), meat meal and the legumes, soya beans, peas and beans.

The foods providing protein of high biological value are of greatest importance in the feeding of calves and non-ruminants.

Since ruminants, other than young calves, have a much greater capacity for bulky, fibrous foods, it is, in practice, easier to include a wide variety of vegetable foods in their diet than is the case with pigs and poultry. Cows being fed for high milk yields may be placed in an intermediate category, and the investigations of the Hannah Institute for Research in Dairying have shown that insufficiency of lysine may have a limiting effect on milk production. It is suggested that the rations of dairy cows should always include some foods of high lysine content, such as high quality dried grass, fish meal, meat meal, blood meal, yeast, soya bean meal, bean meal, etc.

From the foregoing observations two principles of special significance to the manufacturer of feeding stuffs may be deduced: as wide a variety of materials as possible should be included in every compound feeding stuff, and special attention should be paid to the half dozen important amino-acids.

BLOOD MEAL OR DRIED BLOOD

Compared with the other feeding stuffs of animal origin the characteristic properties of blood meal are its very high protein and low mineral content. These are important points in the proper use of these materials and the percentage figures of their composition should be noted. The figures given in the following table are representative of the different foods but they are

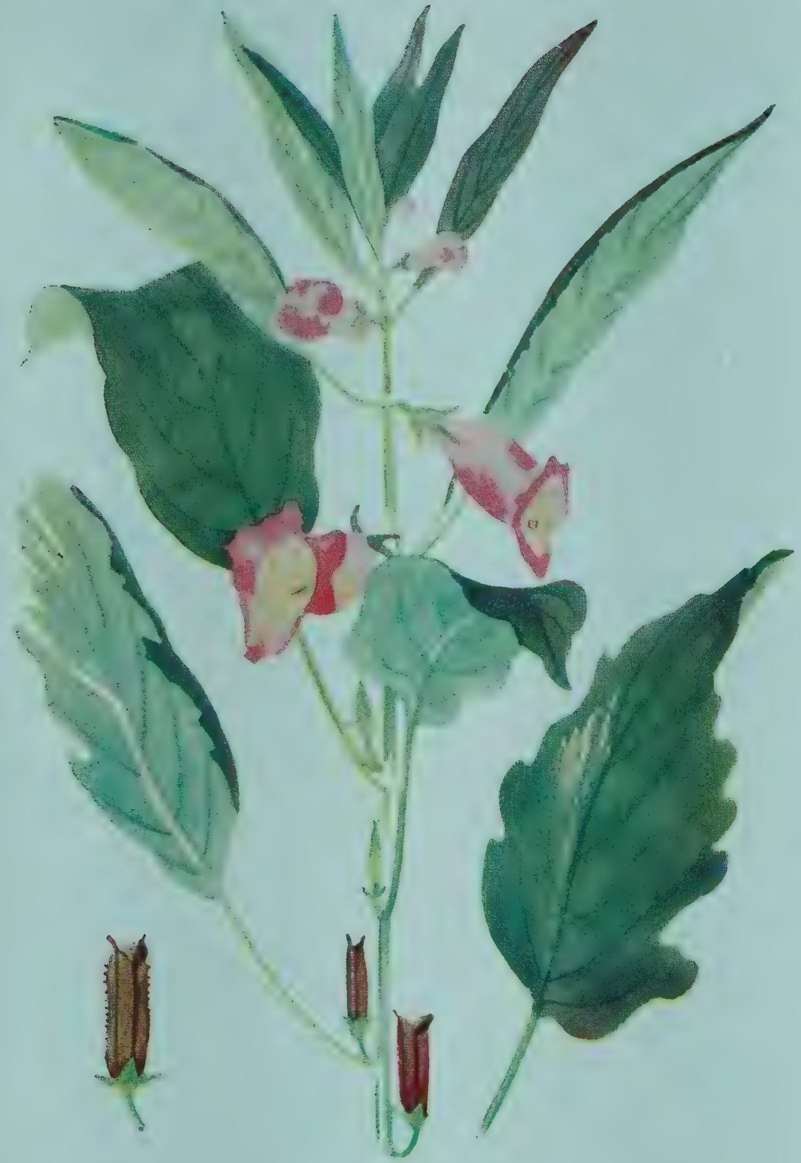


FIG. 19.—Sesame (*Sesamum indicum*). Sesame is also known as benne, teel, gingili and by other names. Original locality not known. Now produced in China, India, Africa, Japan, Java, Thailand, Egypt, Mexico and elsewhere. Seeds are white and dark-coloured, commercially known as 'white and black'; the white yield oil superior to that from the 'black'. In general, used for the same purpose as olive oil.

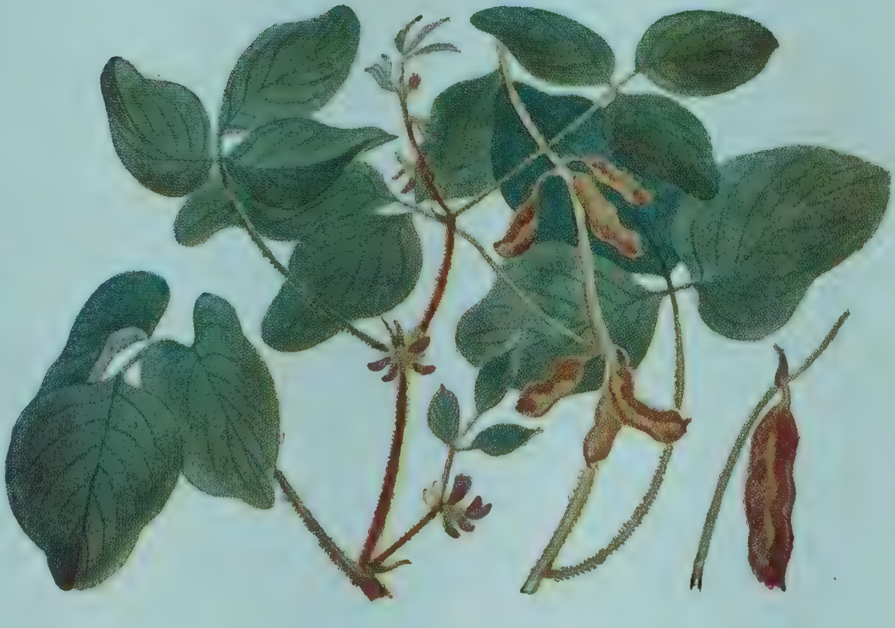


FIG. 20.—Soya Bean (*Glycine hispida*). One of the world's most important oilseed crops, a staple food of the Orient. Indigenous to the Far East: now cultivated elsewhere, particularly in the United States. Referred to in Chinese materia medica written over 4,500 years ago. Introduced into the U.S.A. about 1800, but did not begin to attract attention until 1900. Seed first imported into England from East in 1908. Bean made into flour, sauce (soy), vegetable milk and cheese, adhesives and plastics, paper size, textile fibre; oil used for many edible and non-edible purposes; cake used for animal food and as fertilizer.

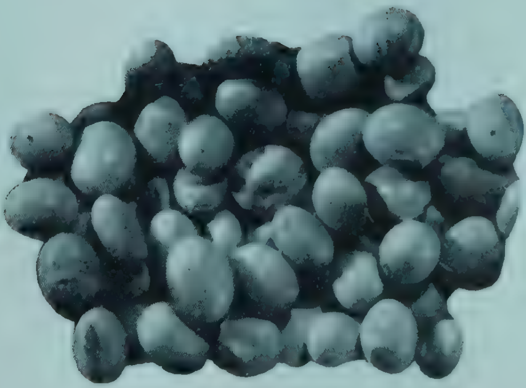


FIG. 21.—Soya beans: actual size.

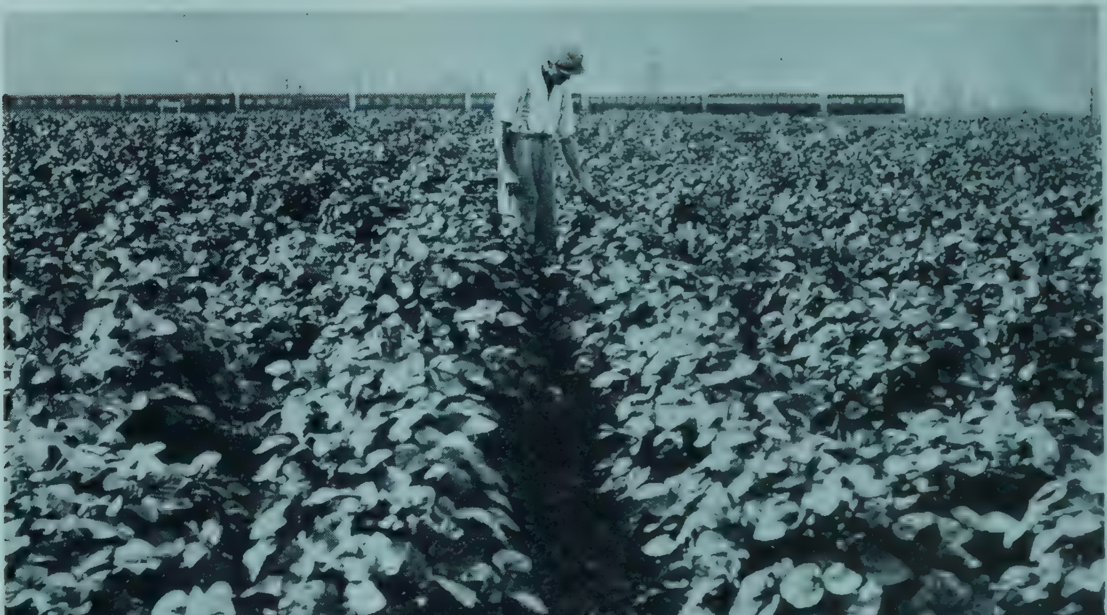


FIG. 22.—Soya bean cultivation.

subject to considerable variation according to the method of processing the raw material.

	Crude Protein	*Oil*	*Soluble Carbo-hydrates*	*Total Minerals*	*CaO*	P_2O_5	*Cl*
	per cent	per cent	per cent	per cent	per cent	per cent	per cent
Blood meal	80	0·8	1·5	2·7	0·1	0·3	0·7
Meat meal	65/70	5/10	—	3·8	0·4	0·7	0·3
Whale meat meal	60/65	10/15	—	20/25	0·05	1·0	0·03
White fish meal	60/64	4·5	2·1	25·0	10·0	8·0	1·0
Meat and bone meal	50	10·0	5·0	23·0	11·0	9·0	1·0
Dried skim milk	33	0·3	49·0	8·0	1·5	2.0	1·0

The composition of any feeding stuff prepared from the carcases of animals varies in accordance with the proportions of muscle and other organs of protein structure, fat and bone that are incorporated in it. The feeding value is also affected by the heat treatment to which it is subjected, high temperatures having the effect of reducing the digestibility of most, if not all, animal proteins and of destroying some of the amino-acids, the valuable lysine being one of the first to be damaged. The proteins of blood deteriorate rapidly under heat, and blood meal dried by the low-temperature process is of much higher feeding value than that which has been exposed to high temperature heating.

Blood meal contains only very small amounts of minerals and this should not be overlooked when blood meal is being brought in to replace any of the mineral-rich protein foods. The proportion of blood meal required is never more than 5 per cent—usually less. Larger amounts will almost certainly be wasteful and are very liable to cause scouring. Higher proportions may be included in milk substitutes for calves, but the cost is likely to make it uneconomic to do so.

BONE MEAL

It is significant that, in the First and Fourth Schedules of the Fertilisers and Feeding Stuffs Act, 1926, all the meals made from bone, meat and bone or meat are described as *feeding* bone flour, *feeding* bone meal, *feeding* meat and bone meal, *feeding* meat meal. It is most important that the origin of these materials be ascertained and that they should be bought for feeding purposes only if guaranteed as *feeding* meal. The definitions given in the Fourth Schedule of the Act should be noted. Feeding bone meal is there defined as ‘ commercially pure bone, raw or degreased, which has been ground or crushed ’. A product thus treated could therefore be sold as a feeding bone meal that had not been sterilised in the course of processing. For this reason it is necessary for the merchant or manufacturer of feeding stuffs to take the further precaution of buying only material carrying a certificate of sterilisation. Linton and Williamson (3) and (4) mention a low temperature bone meal manufactured in Scotland under licence. Apart from such a special product, sterilised steamed bone flour should always be used in preference to bone meal.

STERILISED STEAMED BONE FLOUR

Sterilised steamed bone flour is made by grinding and then sterilising by steam the clean bones from which the fat and nitrogenous matter has been removed by boiling. It consists therefore of the ' minerals ' of the bone, mainly calcium and phosphorus, with a little magnesium and an insignificant fraction of nitrogen. The calcium and phosphorus are, of course, in the same proportions as in the original bone and an average sample of steamed bone flour shows, on analysis, about 46 per cent of calcium as CaO and about 31 per cent of phosphorus as P_2O_5.

Sterilised steamed bone flour is used in mineral supplements for all livestock.

FISH MEAL

Fish meals are made from the waste, heads, flesh, bones, etc., from the preparation of fish for human consumption and also from fish that have been through a special process for extracting ' herring oil '. Material which, through staleness or other causes, is unsuitable for the feeding stuffs market, is also dried and is directed to the fertiliser market. It should never be used, although it has on occasions been offered, for feeding purposes.

The characteristic flavour and smell of fish oil can easily be transmitted to the fat of animals fed on it, and since any trace of this taint is highly objectionable the Fertiliser and Feeding Stuffs Act, 1926, defines three categories of fish meals and in doing so prescribes the maximum percentage of oil permissible in a meal described as *White Fish Meal.* In the wording of the Act (Fourth Schedule) : ' White Fish Meal is a product (containing not more than 6 per cent of oil and not more than 4 per cent of salt) obtained by drying and grinding or otherwise treating waste of white fish, to which no other matter has been added.'

In the same Schedule of the Act the definition of *Fish Meal; fish residue meal* is given thus: ' A product obtained by drying and grinding or otherwise treating waste of fish, to which no other matter has been added.' In this case no restriction is placed on the kind of fish that may be used or on the amount of oil or salt. In point of fact, fish meal of good quality can be produced from herrings and similar fish when the extraction of the oil is efficiently carried out but, though fish meal from the herring-oil plants of Norway and elsewhere need not be neglected, great care must be taken that meals of high oil content are not included in compounds for fattening pigs, laying hens or milking cows.

Because *White Fish Meal* contains such a large proportion of the fish bone the mineral content is high—approaching 25 per cent. The proportion

The by-products of butter and cheese making are separated milk, buttermilk and whey. In the liquid form these are extremely valuable foods, but the obvious difficulties of handling and transport and their rapid souring and other forms of deterioration restrict the range of their use. Methods of evaporation are used to preserve these foods and several products are marketed having characteristic differences in composition and feeding properties.

Buttermilk and whey have sometimes been condensed down to a thick consistency and marketed under the names of Semi-solid Buttermilk and Whey Paste. The composition (1) of these is approximately :

	Dry Matter	*Crude Protein*	*Fat*	*Carbohydrate*	*Ash*	*Starch Equivalent*
	per cent	per cent	per cent	per cent	per cent	per cent
Semi-solid buttermilk	30	12	2½	13	2½	27
Whey paste	46	6	¾	35	4	34

Modern drying methods, properly performed, have only insignificant effects on the nutritive properties of milk. The three systems in general use are the spray drying method, the roller method in a partial vacuum and the roller method on rollers exposed to the air. The effects of the heating involved are a little greater on the open roller than on the enclosed roller which in turn has slightly more effect than the spray dryer.

The solubility of the proteins is reduced on the open roller, but only to a very small extent. The vitamin C is reduced by about one-third. On the other side of the account, the bacterial condition of the milk is very much improved by the drying and from this point of view dried milk is a much safer food than raw milk.

The small quantities available and the cost of milk products confine their use to those animals that give the highest return for these high quality foods. Calves, young pigs and chicks show immediate response to even small additions to their diets.

Cod Liver Oil

The value of cod liver oil in the feeding of farm animals rests in its richness in the vitamins A and D. Until recently the practice of mixing cod liver oil into compound feeding stuffs during their manufacture was general. It has now been shown that the vitamin potency may be almost entirely lost through oxidation in a few days, or at the best in one or two weeks, under these conditions and the inclusion of cod liver oil in manufactured compounds or mixtures it is certainly wasteful and possibly useless as a means of supplying vitamin A. It is therefore of much less importance to the manufacturer than formerly, and the development of the grass drying industry as well as the production of vitamins A and D synthetically in a concentrated powder form has made reliance on cod liver oil unnecessary.

feeding bone meal that had not been sterilised in the course of processing. For this reason it is necessary for the merchant or manufacturer of feeding stuffs to take the further precaution of buying only material carrying a certificate of sterilisation. Linton and Williamson (3) and (4) mention a low temperature bone meal manufactured in Scotland under licence. Apart from such a special product, sterilised steamed bone flour should always be used in preference to bone meal.

STERILISED STEAMED BONE FLOUR

Sterilised steamed bone flour is made by grinding and then sterilising by steam the clean bones from which the fat and nitrogenous matter has been removed by boiling. It consists therefore of the ' minerals ' of the bone, mainly calcium and phosphorus, with a little magnesium and an insignificant fraction of nitrogen. The calcium and phosphorus are, of course, in the same proportions as in the original bone and an average sample of steamed bone flour shows, on analysis, about 46 per cent of calcium as CaO and about 31 per cent of phosphorus as P_2O_5.

Sterilised steamed bone flour is used in mineral supplements for all livestock.

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The oil itself has a high energy value, but its detrimental effect on carcase quality and on the butterfat of milk prevents its use in quantities that would make its inclusion in feeding stuffs economically worth while.

Cod liver oil, of high vitamin potency, has valuable uses in the nutrition of farm livestock, but to retain its full value it must be kept in an airtight container free from contact with the air, cool and away from strong light.

OTHER FEEDING STUFFS

DRIED GRASS

Grass meal is very variable in quality and frequent sampling and analysis of consignments have to be made when the proportion in a compound is more than a very small fraction. The adjustment of quantities in a mix to compensate differences in the composition of one ingredient is troublesome and, by slowing down production, can be expensive. Standardisation by blending would appear to offer possibilities of making use of grass meal more attractive to manufacturers, whether for inclusion in compounds or for cubing and pelleting by itself.

The dominant factor in determining the chemical composition of grass is the stage of growth. From the emergence of the first shoot to the ripening of seed there is a decline in the proportion of digestible material and a corresponding increase in indigestible fibre and to a lesser degree in other components. The earlier (in stage of growth) the grass can be eaten, therefore, the higher is its nutritive value: the following figures (5) of composition of grass cut and dried at different stages of growth may be taken to illustrate the changes that occur as growth proceeds:

Stage of Growth of Grass when Cut and Dried	*Crude Fibre*	*Digestible Fibre*	*Crude Protein*	*Protein Equivalent*	*Starch Equivalent*
	per cent	per cent	per cent	per cent	per cent
Very leafy . . .	17·7	13·3	18·7	13·6	54·1
Leafy	20·9	15·9	15·0	9·3	52·7
Early flowering . .	24·4	18·8	12·1	6·8	51·2
In flower and stemming .	24·4	18·6	10·4	5·5	49·5
Good meadow hay (*early flowering*) .	26·6	18·2	10·0	5·0	40·5
Good meadow hay (*flowering stage*) .	28·7	17·9	7·6	3·1	35·6

The figures for a good meadow hay cut at the early flowering stage and meadow hay cut at the flowering stage are added at the bottom of the table to bring out the close similarity in chemical composition between grass dried by artificial heat and by the normal methods of haymaking, if they are cut at the same growth stage.

The figures given in this table do not represent the extremes of variation that are found in dried grass. Samples have often, on analysis, been found to contain considerably higher percentages of protein, and also much lower. It may be observed that the ratio of protein to starch equivalent is not the same at all stages. With increasing age of the grass, the starch equivalent does not fall off as rapidly as the protein. Consequently, the nutritive ratio is higher in the case of young herbage than in older material, and a low protein content cannot be compensated by feeding additional quantities of poor quality dried grass.

The biological value of the proteins of dried grass is very high, a large variety of vegetable proteins being provided by the botanical composition of a mixed herbage.

The mineral constitution is good. Dried grass, consisting of the leafy parts of the plants, has a high ratio of calcium to phosphorus, in contrast to seed, in which phosphorus predominates.

	CaO per cent	P_2O_5 per cent	Ratio $CaO : P_2O_5$
Good dried grass (1)	1·20	0·75	1 : 0·6
Wheat middlings (1)	0·13	1·50	1 : 11½
Oats (1)	0·14	0·81	1 : 6

VITAMINS OF DRIED GRASS

All fresh, green, leafy plants contain carotene, a substance that is converted into vitamin A by the animal. A diet that includes a good proportion of green vegetation—grass, kale, cabbage, sugar beet tops, etc.—normally supplies much more carotene than is required by the animal for its daily needs, and in the summer months grazing animals are able to accumulate (principally in the liver) enough vitamin A to satisfy their needs for most of the winter. Modern methods of artificially drying green crops cause very little deterioration of the carotene so that newly dried grass has nearly the same vitamin A value, per lb. of dry matter, as the fresh green herbage. Carotene is quickly destroyed, however, by oxidation when exposed to daylight and air, and the reaction is accelerated by warmth. It is therefore essential to store dried grass out of the light, in a cool place, and protected from the atmosphere as much as possible. It should be the aim, when arranging the storage, to minimise disturbance of stored material or of the air surrounding it when withdrawals from the store are being made, because oxidation of the carotene is increased by bringing fresh air into contact with it.

The loss of carotene during storage, and its uncertainty, makes the carotene content of dried grass a somewhat unsatisfactory basis for fixing a selling price. The carotene value at the time of sale can have dropped by as much as 75 per cent since the time of drying the grass; losses of from 25 per cent to 50 per cent are common. Even if it were practicable to carry out a test for carotene on each consignment at the time of sale, there would be no certainty that the carotene value at the time of feeding would be comparable: it would almost certainly be appreciably less as regards the greater part of the delivery because the movement from store to farm would cause considerable aeration of the material and, consequently, stimulate oxidation. When carotene content is important, as in the feeding of pigs and poultry kept on an ' intensive ' system, allowing them little or no access to fresh green food, some guide to the probable carotene level may be provided by consideration of three points:

Firstly, a good carotene figure at the time of manufacture is proof that the carotene content was good *at that time*. This assumes that the sample was representative of the bulk and that the bulk was uniform with regard to the distribution of carotene in it. Secondly, when a reliable figure of carotene content at the time of manufacture is not available, the protein percentage figure is almost as useful a guide because high protein can only be found in dried grass made from young, leafy herbage. In such material the carotene content is also at its highest and a high protein figure is, for all practical purposes, a guarantee of high carotene at the time of cutting. Thirdly, the carotene value at any later date depends very largely upon the conditions of storage, to which reference has already been made. Carotene being closely associated with chlorophyll, it is *probable*, but not certain, that a good green colour will be associated with a fair carotene content. Conditions that favour oxidation of carotene also bring about the bleaching of the green pigment, but more slowly. If the dried material has lost its colour through bleaching it is certain to have also lost its carotene, but it is possible for it to lose the carotene before the green colour has gone.

Since dried grass is used as a source of vitamins in place of cod liver oil it should be clearly understood that dried grass does not contain any vitamin D, the ' sunshine vitamin '. Animals kept entirely under cover are not protected from vitamin D deficiency by dried grass, but require also cod liver oil or one of the synthetic products. Dried grass supplies vitamins of the B complex, notably riboflavin, which increases its value for poultry and pigs in particular.

Herbivorous animals are adapted to subsist entirely on grass, fresh or dried, and it can constitute any proportion of their diet. Since in cattle and sheep rumination is liable to be hindered by food given in a finely divided condition, and since dusty foods are particularly objectionable to horses, there is an advantage in feeding dried grass to these classes of livestock in its natural length, without grinding. High quality dried grass is a valuable food for calves and all young stock.

In the feeding of pigs and poultry, the fibre content of the dried grass restricts the amount that can be fed, and a high proportion of it in the daily ration is not eaten very willingly: too much dried grass has been found to reduce total consumption of food and live weight increase and egg production. Woodman (1) recommends that not more than one-third of the ration of pigs should be given as dried grass up to 150 lb. live-weight, and not more than one-quarter above this weight. Unless the material available is of very high quality, it is probable that 10 per cent is a satisfactory proportion and this would amply cover the carotene requirements.

For poultry, the proportion should rarely exceed 10 per cent. Halnan (2) gives 7 per cent as a fair allowance for all ages of poultry. This would provide fully the total carotene requirements.

CLOVER MEAL AND LUCERNE (ALFALFA) MEAL

The value of both these products depends upon the proportions of leaf and stem that is included. In finely ground meals no indication of this can be obtained by ocular examination. Good samples, containing a high ratio of leaf to stem, are valuable as sources of protein and calcium. The carotene value, as in the case of dried grass, depends upon the treatment to which the green crop has been subjected after cutting, but it tends to be rather lower than in dried grass.

DRIED SUGAR BEET PULP

The dried residue of the sugar beet, after the sugar-extracting process, contains most of the nutritive properties of the raw root other than the sugar. Its chemical composition indicates that it might be expected to replace cereals, if its slightly lower protein were balanced by some other food. The protein of sugar beet is low in total quantity and is of low biological value, being notably poor in lysine. Not much more than half the protein is digested by cattle and only about one-third is digested by pigs. It is essentially a carbohydrate food. The crude fibre figure is about 18 per cent but the fibre is well digested, even by pigs. The nutritive ratio is thus very wide.

Molasses is sometimes added to the dried pulp, giving the product a still wider nutritive ratio and, though making it rather more palatable, slightly reducing its starch equivalent.

Dried sugar beet pulp swells strongly when it is wetted and for this reason it is unwise to feed it in any quantity without first soaking it. Ten pounds of the dried pulp absorbs 2½-3 gallons of water.

For dairy cows a maximum of 8 lb. per day has been generally recommended. Fattening cattle will make good use of as much as 12 lb. (weighed as dried pulp).

Pigs digest the fibre well but the pulp is so bulky that the total food consumption and the rate of live-weight increase fall off if more than about 1 lb. per day is given to fattening pigs. Sows do well with as much as 2 lb. per day, and the moist soaked pulp appears to be relished once they have acquired a taste for it. Young pigs do not thrive on it and it has been found unsatisfactory for all classes of poultry.

MOLASSES

The manufacturer of compounds is interested in molasses principally on account of its usefulness in binding dry meals into cubes and pellets, of which it may constitute as much as 10 per cent of the weight.

The material as received from the sugar factory is a syrup containing approximately 75 per cent solids and 25 per cent water. The dry matter consists mainly of the carbohydrate (sugar) that cannot be crystallised out in the sugar manufacturing process. There is only an insignificant amount of protein and between 5 and 7 per cent of ash (' minerals '). The latter contains a high proportion of potash which is largely responsible for the laxative action of molasses.

The starch equivalent is between 51 and 52 per cent and the protein equivalent about 0·6 per cent. Molasses therefore contributes only to the starch equivalent figure in the calculation of the nutritive value of a compound. Since its starch equivalent is comparatively low, the effect of adding molasses is usually to depress slightly the starch equivalent figure of the mixture. Against this may be set the increased palatability and prevention of dustiness.

POTATOES

Though raw potatoes can be given to cattle and cooked potatoes are a valuable food for pigs, potatoes become of direct importance to the manufacturer of feeding stuffs only in one of the dried forms.

The sliced, dried fingers known as ‘ cosettes ’, which have not been cooked, are suitable for cattle and sheep, but for pigs the cooked ‘ slices ’ and ‘ flakes ’ are much more satisfactory. Some form of cooking is essential in the preparation of potatoes for pig feeding even though the cooked material is afterwards dried.

Potatoes are a starchy food, very low in calcium, but when adequately balanced by protein- and mineral-rich substances they are a useful form of carbohydrate for all livestock.

SAGO PITH MEAL

This meal is obtained from the fruit of the sago palm. Its nutritive value lies in its high carbohydrate content (80 per cent). It provides practically no protein and very little oil or minerals. The meal is very digestible and can be included in mixtures or compounds for all livestock.

TAPIOCA FLOUR (CASSAVA MEAL. MANIOC MEAL)

The properties of this meal are very similar to those of sago pith meal. The best grades are even richer in carbohydrates and have a starch equivalent of about 83. Like sago pith meal, tapioca flour can be used in any balanced mixture and is particularly useful for fattening pigs or cattle, producing a firm, white fat.

DRIED YEAST

Dried yeast is valuable as a source of protein of high biological quality. It is well supplied with minerals but the ratio of calcium to phosphorus is low: an average sample contains about 0·3 per cent CaO and 5·0 per cent P_2O_5.

A distinction must be drawn between unextracted dried yeast and the extracted material. Unextracted dried yeast is an excellent source of the B vitamins, and has a crude protein content of 41-42 per cent. The extracted yeast has been processed in the preparation of the marmite type of extract and is of much lower value. It has a low vitamin potency and contains only about half the amount of protein found in the unextracted material.

Dried yeast can be included in compounds for all livestock. On account of its high protein content it is seldom necessary to include more than 8-10 per cent and 5 per cent is usually found sufficient. In any case, its bitter taste may make animals refuse it if introduced in too large amounts.

SOME ADVANTAGES OF CUBES AND PELLETS

Compound feeding stuffs composed of a considerable variety of ingredients possess an advantage over more simple mixtures largely on account of the greater variety of amino-acids and, probably, of trace minerals. In a loose meal, however, many of these ingredients tend to segregate and some of the benefit which should result from the variety may be lost as a result of animals not getting the complete mixture. Moreover, in mixtures in the form of meals some animals, particularly poultry, pick out certain foods and neglect other less palatable portions : dusty material, particularly, is disliked by most animals and is discarded if possible and, of course, dust is objectionable in many other ways. Consequently, the use of loose meals frequently results in considerable waste. Even though mixed meals are moistened before feeding some separation may often have taken place in transit or storage, and fine dust often tends to become sticky or pasty when moistened.

For such reasons as these the process of cubing and pelleting was developed and it offers very definite advantages. Cubes or pellets reduce the tendency of many animals to bolt their food as they do frequently when offered meals, and animals clean up better when their concentrates are given in the form of cubes or pellets. The labour of mixing meals on the farm can be considerable, and during storage meals are more subject to infestation by insects than are well-pressed cubes and pellets. Mention has already been made of the greater variety of amino-acids, etc. that are provided by the use of a large number of food materials and the compression into cubes probably assists in the preservation of vitamin potency in some degree, although experimental evidence is as yet not very conclusive on this point.

A recent development that should be mentioned is the production of chick crumbs which are increasing in popularity, both because they are more economical to manufacture than chick pellets and because there is some evidence that their finer particles are more fully used by small chicks than the larger pellets.

With regard to the cubing of grass, the problem of dust prevention is of even greater significance than with most compound meals. Dried grass meal is excessively dusty and can give rise to considerable trouble on the farm, particularly in relation to milk production. Moreover, the cubing of grass meal reduces the bulk to such an extent that 1 cwt. of grass cube occupies the same sized bag as ½ cwt. grass meal. Cubes can even be transported in bulk if necessity arises.

The loss of carotene from dried grass has been discussed in an earlier chapter. Efforts have been made to seal the cubes by liquid treatment to prevent this loss but it has not yet been entirely successful. Efficient cooling and cool, dry storage are at present the best preventative.

The question is often asked—what is cubing or pelleting worth to the farmer ? The answer must depend not only upon the above factors but also upon the ability of the farmer to profit by the convenience and saving of labour, reduction of wastage and cleaner working—the last being a particularly important factor in the milking shed.

From the manufacturers' point of view grass cubing is disliked both by factory workers and managers because of the extremely dusty conditions that prevail. This difficulty will probably be overcome and dried grass cubes should have a very useful future if their cost can be kept at a competitive level.

Chapter III

TYPICAL COMPOUND MIXTURES AND THEIR COMPOSITION

THE following are typical formulae for various classes of livestock as at present in use, with notes on their composition.

DAIRY FOOD (WINTER)

per cent	*Ingredients*
15	Bran
15	Flake Maize
10	Crushed Oats
5	Grass Meal
10	Coconut Cake
15	Linseed Cake
15	Decorticated Ground-nut Cake
5	Locust Beans
5	Wheat Germ
5	Minerals

Winter dairy compounds are normally fed in conjunction with a ration of hay, roots and straw and probably with some farmers' grain, particularly oats. A concentrated and fairly high-protein compound is then needed that will blend with oats to give the correct amount of protein and energy value for milk production. If, in addition, some of these maintenance foods are of rather a binding nature, the supplement should be mildly laxative. Moreover, hay and straw tend to produce a rather hard, white butterfat, and the ingredients in the compound can be chosen to counteract this. Maize, grass meal and linseed cake in particular have a softening influence on fat, and grass meal and yellow maize help to produce better colour.

DAIRY FOOD (SPRING)

per cent	*Ingredients*
15	Bran
5	Flaked Maize
30	Crushed Oats
10	Flaked Barley
10	Exp. Palm Kernel Cake
5	Decorticated Cotton Cake
10	Undecorticated Cotton Cake
10	Decorticated Ground-nut Cake
5	Minerals

In spring, when animals go out to grass, their diet undergoes a radical change. Grass, when rapidly growing in the spring flush, has a pronounced laxative action which must be counteracted if high milk yields are to be obtained. Furthermore, rich grass gives a soft, yellow butterfat. The purpose of decorticated and, particularly, undecorticated cotton cake, is to overcome the laxative action of grass and produce a harder butterfat. Actually there is not the same need for high protein in the Spring Dairy Ration, since a large part of protein requirements will be supplied by grass itself.

PIG REARING

per cent	*Ingredients*
20	Weatings
23¾	Maize Meal
20	Barley Meal
10	Sussex Ground Oats
2½	Grass Meal
5	Dried Whey
5	Soya Bean Meal
5	Ext. Ground-nut Meal
7½	Fish Meal
1¼	Minerals

Add vitamin B supplement and vitamin D_2.

A weaner's ration must have a concentrated and digestible nature also, including the necessary mineral and vitamin supplements, so that it may fully replace the sow's milk. The young pigs cannot cope with much indigestible fibre and must receive a ration well balanced between digestible starchy foods and good quality protein. Animal protein as supplied by fish meal is an essential and soya bean meal is probably the best of the vegetable protein meals. The purpose of grass meal is to supply vitamins A and B, while dried whey is a good source of the B vitamins also. Extra vitamin concentrates are desirable, particularly as regards vitamin D, the latter being most necessary if the pigs do not go outside.

PIG FATTENING

per cent	*Ingredients*
20	Weatings
45	Barley Meal
20	Sussex Ground Oats
10	Maize Meal
2½	Ext. Ground-nut Meal
2½	Meat Meal

As the pig gets older its requirements for protein drop proportionately, and it requires a largely carbohydrate diet in order to give maximum live-weight increase. Naturally there should not be a sudden change from a rearing ration to the fattening ration. Four pig rations are desirable—first and second rearing rations and first and second fattening rations—with progressively decreasing protein. In the final stages of fattening the pig could, in fact, be given a diet consisting mainly of barley. The fattening ration shown above is suitable for pigs up to 200 lb. live-weight; the high proportion of barley should ensure the production of firm, white fat. In the later stages, barley could replace ground-nut and meat meal and finally maize.

CHICK MASH

per cent	*Ingredients*
15	Weatings
30	Maize Meal
7½	Barley Meal
10	Sussex Ground Oats
5	Wheat Germ
5	Maize Gluten
3¾	Dried Milk
3¾	Dried Whey
2½	Grass Meal
5	Soya Bean Meal
10	Fish Meal
2½	Minerals

Add vitamin D_3 and vitamin B supplement.

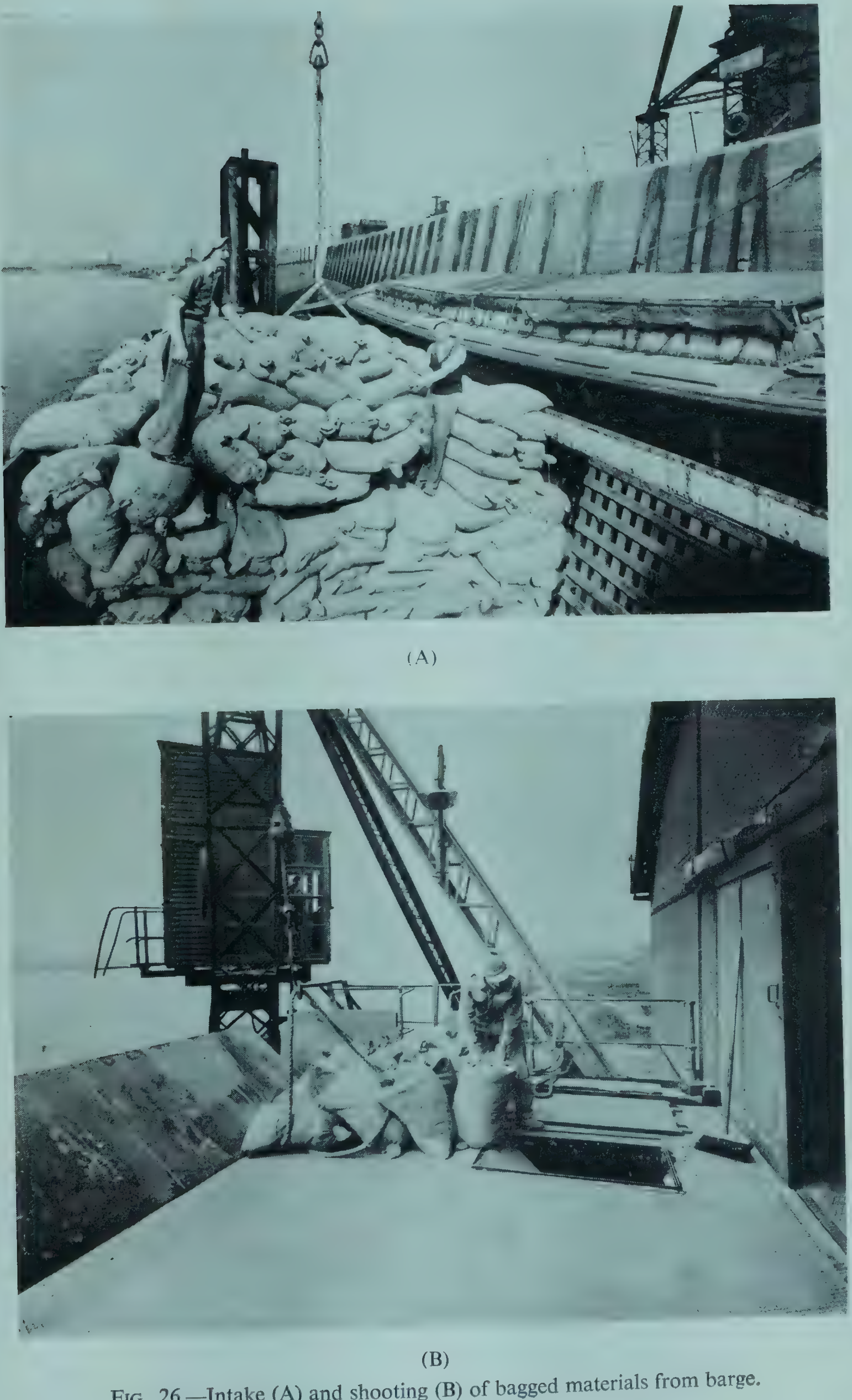
As with pig rearing, the ration of the young chick must be compiled with very great care. Its delicate digestive system cannot cope with much indigestible material and it requires a concentrated, digestible food containing all the protein, minerals and vitamins necessary for its health and growth. For this reason dried milk products are particularly valuable in chick-rearing mashes, while grass meal is most valuable as a source of vitamin A. Every attention should be paid to correct supplementation with B vitamins and vitamin D_3. Fish meal and soya bean meal in the proportions used should provide the necessary protein of good quality and carbohydrate requirements are largely met by maize meal.

LAYERS' MASH

per cent	*Ingredients*
20	Weatings
20	Maize Meal
15	Barley Meal
11¼	Sussex Ground Oats
5	Grass Meal
5	Molasses
5	Coconut Cake
7½	Ext. Ground-nut Meal
7½	Fish Meal
3¾	Minerals

Add vitamin D_3 and vitamin B supplement.

The laying bird also requires a concentrated ration, because its food capacity is limited to something of the order of 4-5 oz. per day; this amount of food must provide the bird's own requirements as well as that for egg production. Again, only digestible ingredients should be used, well-balanced as regards the starchy foods and protein. Mineral requirements are, of course, heavy for efficient egg production, and vitamin supplements are most necessary to maintain the health of the bird and to provide for high egg production and good hatchability.



(A)

(B)

FIG. 26.—Intake (A) and shooting (B) of bagged materials from barge.

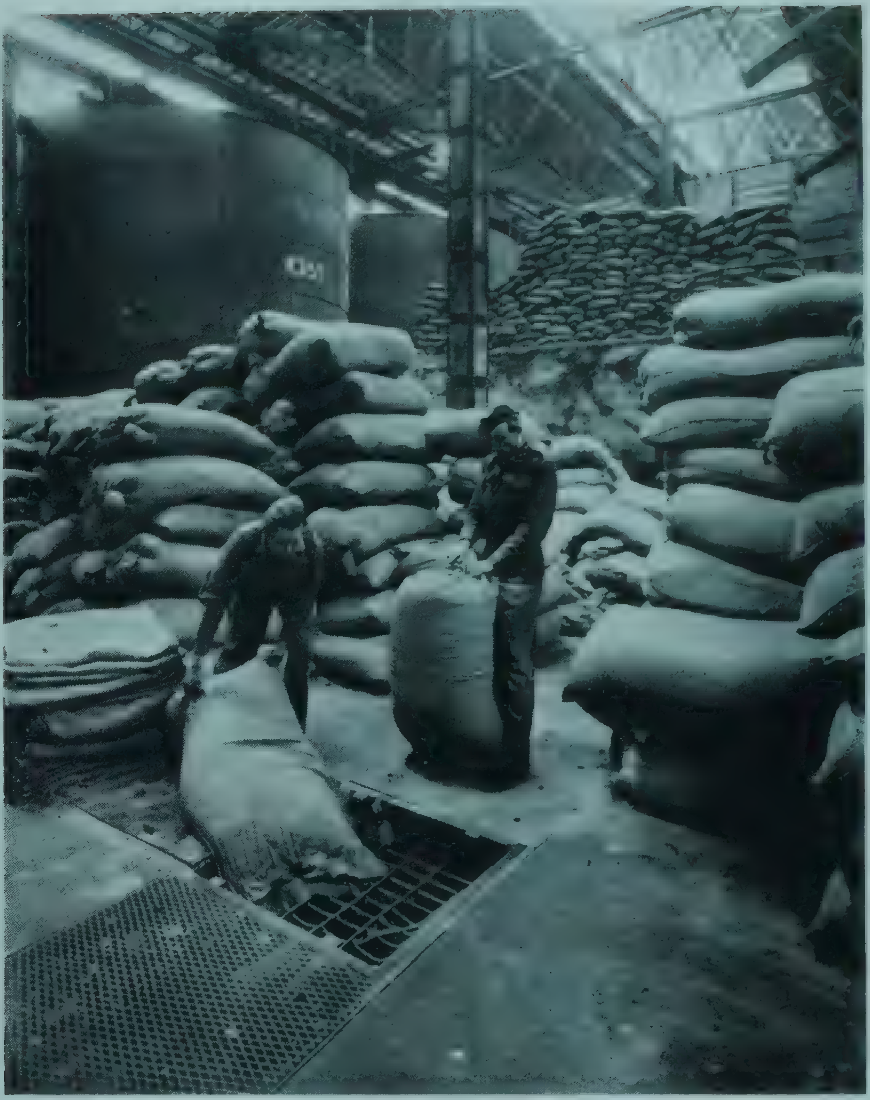


FIG. 27.—Shooting of bagged materials from intake warehouse to process bins.

Chapter IV

THE INTAKE AND STORAGE OF RAW MATERIALS

INTAKE OF BAGGED MATERIALS

In this country, most home produced and imported raw materials arrive at compound mills in bags or sacks by road, rail or water transport. The major exception is grain, which arrives at port mills in bulk by ship or barge and sometimes at inland mills by bulk road or rail wagon.

At times, grain is stored in sacks but usually it is handled in bulk and stored in silos or bins. At smaller mills, all other materials, except kibbled oilcakes and expeller flakes, are almost always stored in bags. At larger mills, bagged materials are sometimes handled in bulk or stored in bins. In most cases, however, the size of these bins is restricted by the nature of compound materials, and, therefore, even in large mills, a high proportion of the total intake is stored in bags.

BAG HANDLING MACHINERY

Machinery for handling bagged materials is of four types :

(*a*) Friction hoists and derricks.
(*b*) The Donald elevator for barges.
(*c*) Sack elevators.
(*d*) Inclined and horizontal sack conveyors.

(*a*) Friction Hoists

The simple friction hoist is still largely used in small mills; it consists of a barrel shaft carrying a friction wheel which makes contact with a constantly rotating friction pulley on the driving shaft. As the barrel shaft is brought into or out of contact with the driving shaft, the bags, attached to a chain or rope connected to the barrel, are raised or lowered. The weight of the chain and bag is held by the friction wheel of the barrel shaft coming into contact with a brake block. For bag handling work, hoists are made in various sizes up to 6 cwt. with lifting speeds up to 600 ft. per minute and a power consumption of 15 h.p.

In small mills, the friction hoist is a cheap versatile and widely used piece of equipment but its liability to cause accidents, its intermittent action and low capacity cannot be compared with the modern continuous sack elevator.

In some cases, particularly in port mills where bags arrive by barge, derricks may be used with slings attached for raising a number of bags at once (Figs. 26 (A) and (B)). The bags are then emptied into conveyors feeding the process bins (Fig. 26 (B)).

(*b*) The Donald Elevator

This is made by Rowson, Drew and Clydesdale Ltd. and is used as an alternative to the derrick for the intake of bagged materials from barges. It is often known as the banana elevator because of its common use for that purpose, and consists of canvas slings attached to crossbars connecting to conveyor chains. The elevator is lowered into the barge and delivers the bags to any floor of the warehouse.

(*c*) SACK ELEVATORS

Sack elevators are of inclined or vertical types, in which the bags are carried upwards on bars attached to endless chains.

A type commonly used for intake purposes in compound mills is the inclined elevator (Fig. 28A). In this type the sacks or bags are placed direct from the wagon on to a stationary ramp, which is of open design and usually made of wood; they are then carried upwards by steel bars on an endless chain running on top and bottom sprockets. Various types of carrier bars are used, running on rollers in tracks adjacent to the chains.

These machines are usually driven at the head end by belt or self contained motor and a safeguarding device is incorporated to prevent the elevator running back in case of failure of the driving mechanism. This may consist of a simple ratchet and pawl or a more elaborate friction cam mechanism.

The bags may be delivered from the bars on to any intermediate floor of the warehouse but, for intake purposes in three or four storey buildings, they should be delivered to the top floor at the point where the bars start their downward movement because usually this floor is the most suitable for the storage of bagged raw materials. This type of elevator, if delivering over the head pulley, is capable of dealing with about 480 bags per hour. The lifting speed is approximately 80 ft. per minute.

The vertical elevator is similar in principle to the inclined type, the bags being carried by bars attached to endless chains. The vertical elevator is enclosed in a steel casing having doors at each floor level, the opening of the door enabling a throw-off plate to tip the bags through the door. This elevator may deliver to any floor and, compared with the inclined type, its vertical position saves floor space.

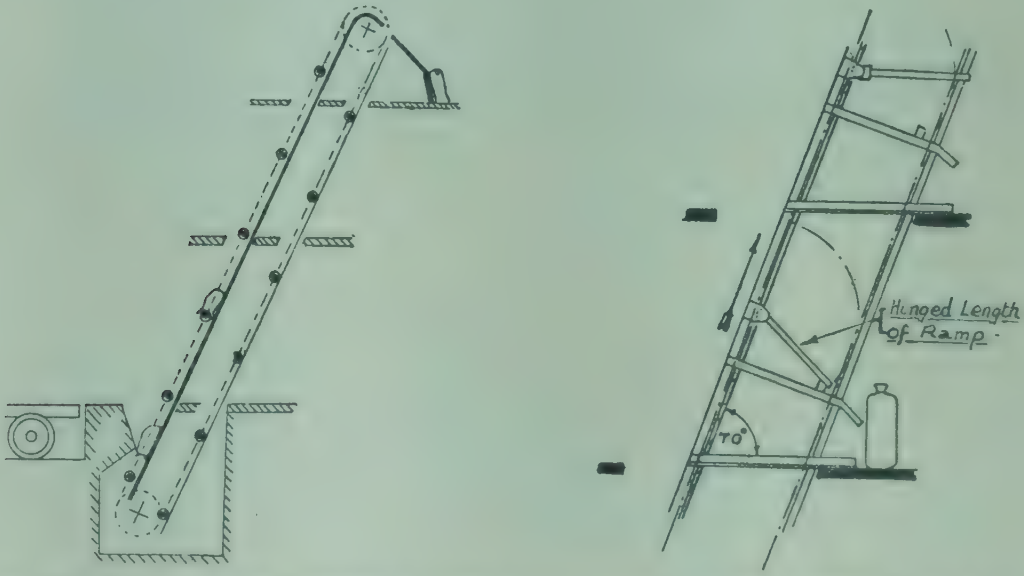


FIG. 28A.—Inclined sack elevator showing arrangement of intake platform and chute, and method of take-off on intermediate floors.

(*d*) INCLINED AND HORIZONTAL SACK CONVEYORS

Inclined sack conveyors differ in design from sack elevators because they carry rather than push the bags up an incline either on bands, bars or slats. Their angle of elevation is much lower than sack elevators and they are used

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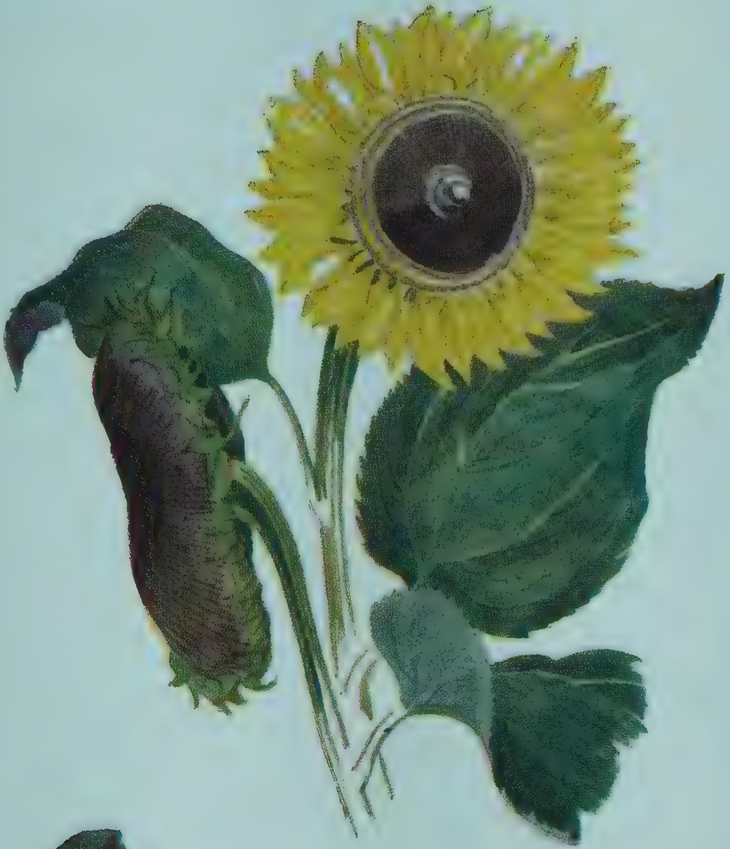
FIG. 23.—Sunflower (*Helianthus annuus*). Native of Central America. Now produced in Europe, China, India, North and South America, and elsewhere. Introduced to British gardens in 1596. First imported into Spain two or three hundred years ago to be used for confectionery; not until mid-nineteenth century was oil extracted from the seeds —by the Russians. Seeds are valuable as poultry food; leaves used as fodder; flowers yield a yellow dye; oil used in edible fats, as salad or cooking oil and also in soap; cake is made into valuable stock feed. In Russia sunflower stalks are burned and high-grade potash salts extracted.



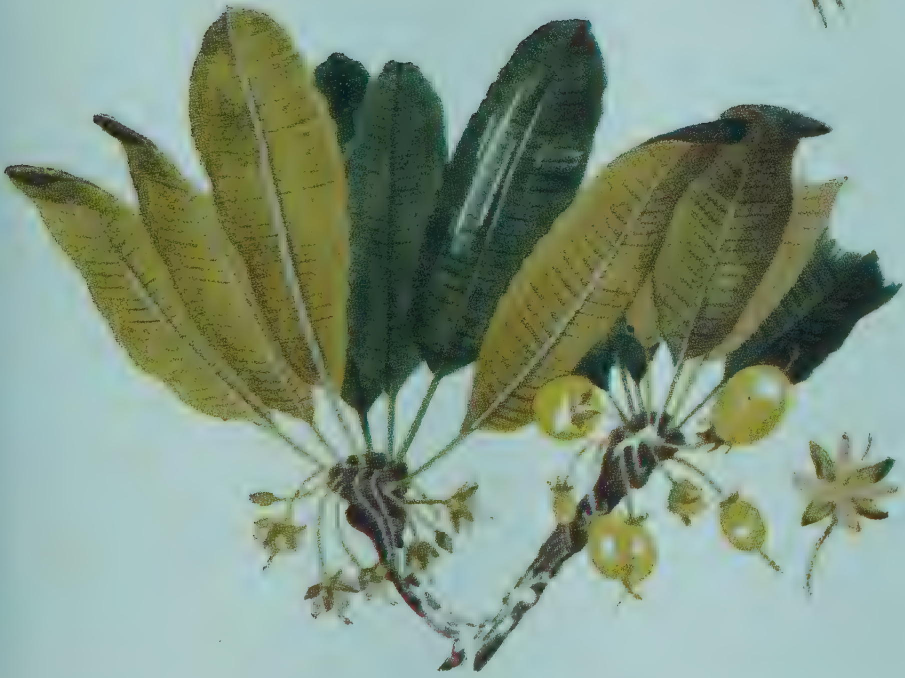


FIG. 24.—The Shea Nut Tree.

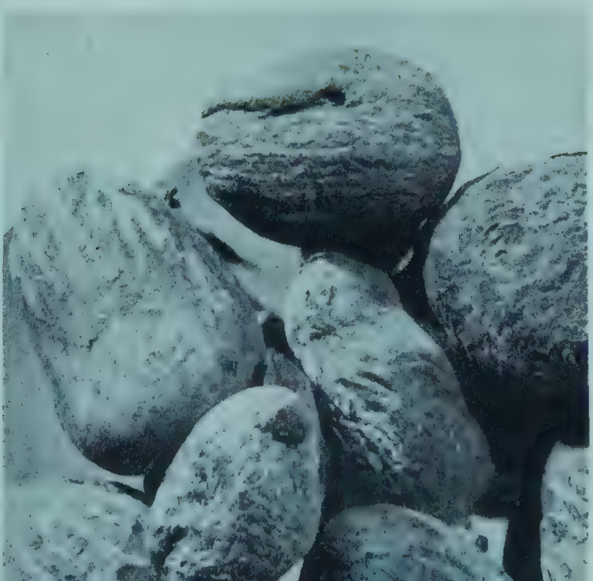


FIG. 25.—Shea Nuts. Shea nuts are the fruit of the large tree *Butyrospermum parkii* (*Sapotaceae* family) and yield a lard-like fat. The tree grows abundantly on the West Coast of Africa and in the Sudans. When dried, a thin, crinkled shell loosely encloses the egg-shaped seed. Shea ut fat is used for cooking fat,

of calcium to phosphorus (7·14 per cent Ca, 3·9 per cent P, or nearly 2 : 1), is useful in balancing foods containing a high proportion of phosphorus.

The composition of the proteins of fish meal makes them particularly effective in supplementing the amino-acids of the cereal proteins. Thus, the minerals and proteins of white fish meal together supply what is specially lacking in a cereal diet and its outstanding value in the feeding of pigs and poultry in combination with cereal products can be attributed to these special properties. This high biological value of the protein, its digestibility and the excellence of the minerals of fish meal show to the greatest advantage in the feeding of all young stock and in milking animals of all kinds.

Although fresh herring-oil may have an appreciable vitamin potency, fish meals used for feeding must, of necessity, contain only a small amount of oil and its vitamin value has practically disappeared by the time the meal is fed. Fish meal cannot be regarded as a source of vitamins.

MEAT MEAL AND MEAT AND BONE MEAL

The Act of 1926 defines ' Feeding meat meal ' and ' Feeding meat and bone meal ', laying down a minimum permissible protein content of 55 per cent and 40 per cent respectively and, in each product, a maximum of 4 per cent of salt. It also specifically excludes the incorporation of hoof or horn from both products. The Act, in fact, confers some degree of standardisation on a material that might otherwise range from almost pure bone to a product containing no bone substance. Generally speaking, the grades produced go up in steps of 5 per cent from 40 per cent to 60 per cent, those below 50 per cent being classed as meat and bone meal. The mineral content is in inverse ratio to the protein unless a larger proportion of fat is included. The Act, by establishing minima for protein contents, in effect sets a rough limit to the proportion of bone that can be included in either product. It will be observed that the percentage of fat is not restricted by the Act and considerable differences occur, depending principally upon the method of treating the raw material. The manufacture of feeding stuffs from waste animal material must conform to the requirements of The Foot-and-Mouth (Boiling of Foodstuffs) Order, 1932, under which the material must be held at boiling temperature (100° C.) for not less than one hour. A small amount of meal is manufactured at a lower temperature under special licence.

The three high temperature processes are known as dry rendering, digestor process and extraction process. The operation in each case reduces the amount of fat; the dry rendering and digestor processes to between 18 and 11 per cent, the extractor process to about 3 per cent. All three processes, employing boiling temperatures for an hour's duration, tend to reduce the value of the proteins and the digestibility may be slightly reduced also by an excess of fat or by too little of it. The meat meals of medium fat content are to be preferred. The proteins of the meals produced by the lower temperature process mentioned earlier are, of course, of higher feeding value.

Fertiliser grades of meat meal should on no account be used for feeding purposes, since their use incurs an unjustifiable risk of disease in the stock consuming them.

WHALE MEAT MEAL

The muscle substance of whales, which are mammals, is of similar composition to that of other mammals. Modern methods of treating the carcases of whales for recovering the oil involve the removal of some of the lower quality proteins and so improve the feeding value of the final product. The composition of the meal varies according to the proportion of bone and fat included in it. The figures given in the following table show the kind of differences that may be expected:

	Crude Protein	*Oil (fat)*	*Ash*
	per cent	per cent	per cent
" A " Grade (Meat only) . .	80–85	3–5	2–3
" B " ,, (Meat and Bone) .	45–65	10–16	20–30
" C " ,, (Bone Meal) . .	18–25	16–?	55–65

Whale oil does not cause taints but, in excess, it may have a softening effect on pig fat—10 per cent of oil is a reasonable top limit. Occasionally samples of poor quality are offered: oxidation of the oil can cause serious troubles and careful analysis is necessary to safeguard the compounder. This applies to all animal oils.

Whale meals are a useful source of the Vitamins of the B group, including B_{12}.

MILK PRODUCTS

To the manufacturer of feeding stuffs, milk and milk products signify only those derived from cows and, apart from the light they throw on the nutritional requirements of their young, the milks of other species of animals may be disregarded.

Milk owes its high nutritive value to the combination of almost all the food requirements of the young animal. It is not absolutely uniform in composition and it can be deficient in certain respects. For example, much of the vitamin content depends on the food and living conditions of the cow, whilst the amount of iron and some other ' trace ' elements is too low to be adequate for the young under some conditions. Nevertheless, the milk products are normally regarded as ' protective ' foods by reason of their high vitamin values, their protein quality and their mineral balance. The deficiencies that have been mentioned only become of serious importance when milk is the whole diet and their correction is then rather in the province of the veterinarian than the feeding stuffs manufacturer.

AVERAGE COMPOSITION OF MILK PRODUCTS (1)

	Crude Protein	*Fat*	*Carbohydrate*	*Ash*	*Approximate Starch Equivalent*
	per cent	per cent	per cent	per cent	per cent
Dried whole milk . .	25	26	37	6½	114
Dried separated milk . .	33	1½	48	7½	70
Dried buttermilk . .	35	7	40	7½	80
Dried whey . . .	12½	1½	70	7½	67

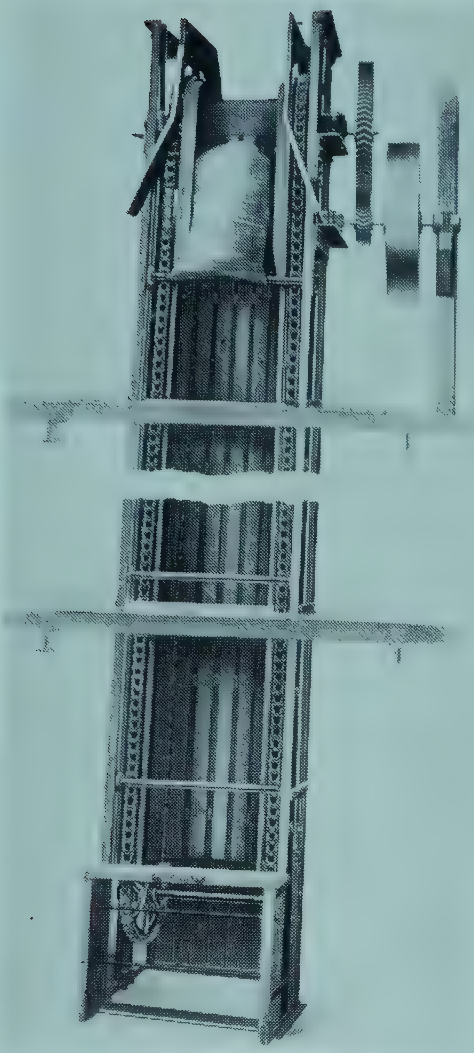


FIG. 28B.—Inclined sack elevator.

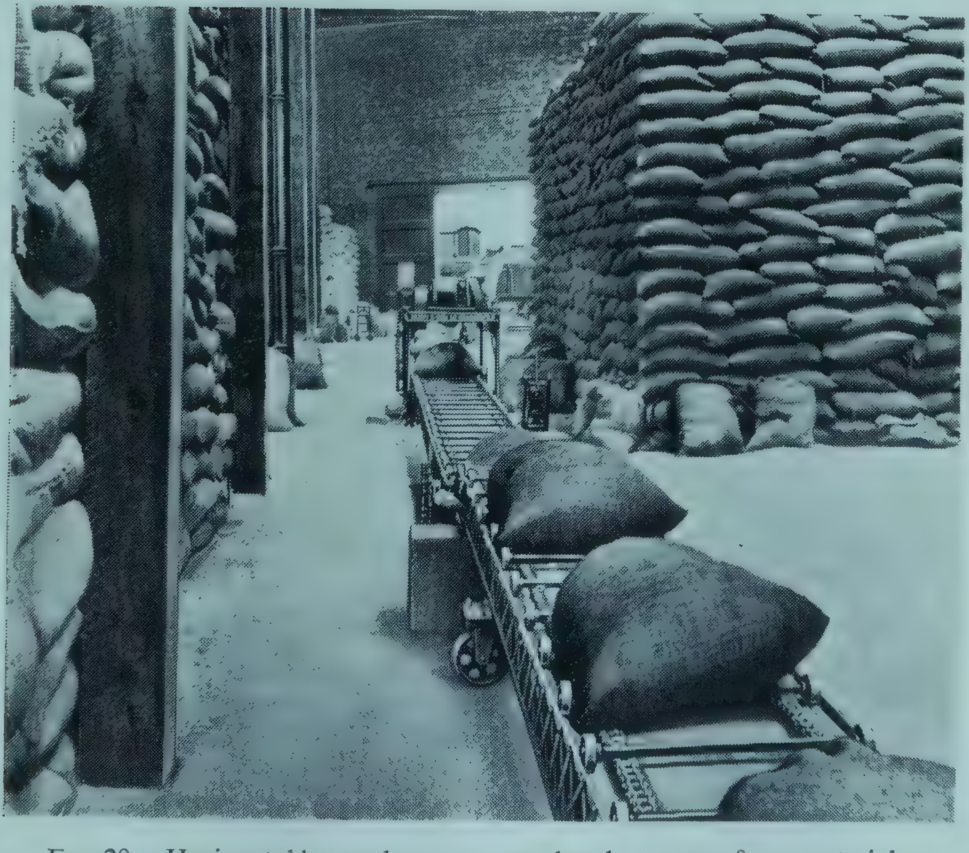


FIG. 29.—Horizontal bar sack conveyor and sack storage of raw materials.

mainly for traversing a yard or other space between the transport vehicle and the warehouse, or for raising bags up slight inclines. Sack conveyors working on a horizontal plane are similar in design (Fig. 29).

In other respects the bar or slat conveyor (Fig. 29) resembles the sack elevator because in each case the bars are fastened to endless chains and are carried on rollers running in side tracks. Conveyor bars are, however, positioned closer together so that the bags are carried on the bars instead of being pushed by a single bar, as in the elevator.

Inclined bar conveyors may also be portable. They are mounted on a wheel chassis and may be taken from place to place by hand and used for stacking purposes inside the warehouse. They are often referred to as mechanical pilers and are adjustable as to incline and height so that the bags may be conveyed to the top of the stacks and placed in position as required by the warehousemen. The portable bar conveyor is driven by a self-contained motor.

The sack band conveyor consists of two end pulleys over which runs an endless belt supported in between by rollers. It is similar in design to the type used for bulk grain, except that the sack type is usually flat and the grain type troughed. The latter is described under bulk conveyors. In the sack type plough-off carriages or diverting boards are used for diverting the sacks or bags down a chute from any point along the conveyor.

STORAGE OF BAGGED MATERIALS COMPARED WITH BULK STORAGE

The advantages and disadvantages of bagged materials storage compared with bulk storage, may be summarised as follows:

(1) Advantages

- (*a*) High initial cost of bulk silos.
- (*b*) Flexibility of floor space for use for other purposes, i.e. for several kinds of raw materials, finished products, or for possible plant extension.
- (*c*) Some overheated materials or those containing high moisture contents may be stored more safely, with better control of their rate of deterioration, provided the bags are stacked in well aerated piles.
- (*d*) If heating does occur bags may be easily isolated from the rest of the pile and moved to a different site.
- (*e*) Difficulties of bin discharging meals that are not free flowing.
- (*f*) Easy stocktaking.

(2) Disadvantages

- (*a*) High handling costs.
- (*b*) Sack hire charges.
- (*c*) Large floor area required.
- (*d*) Damage and waste to the pile caused by rodents.
- (*e*) Fire risk with large piles.
- (*f*) Dust loss through material percolating through bags.
- (*g*) If overheating occurs materials cannot be turned over from one bin to another and temperatures in bins cannot be checked by automatic recording apparatus as in bulk storage systems.

In a few large mills, raw materials are stored in bulk in large open bays with walls on three sides, the materials being conveyed to the process bins by mechanical dumpers on wheels. This method avoids discharging difficulties encountered with compound materials from large bins but it is very dusty in operation, even compared with bag storage.

Fig. 27 shows storage pile of bagged meals in a large single storey warehouse. In some piles the bags are stacked flat up to thirty high, but this is only advisable with dry materials in good condition, such as imported bran and pollards. The height of the pile is limited by the weight per square foot of floor area, depending on the construction of the building. If fire safety appliances are fitted, insurance companies also require the sprinkler heads to be 1 ft. clear of the top bags. Regulations state that the safe floor load must be marked on each floor of the warehouse.

Large piles of this type should have a number of small air passages between them as well as main gangways for trucking. Ventilation is further improved in the case of concrete floors if the bags are stacked on raised, wooden, partition boards. It should be noted that in large piles a fire can smoulder unnoticed for long periods. Small piles on the other hand take up more floor space and it is generally advisable to make piles of medium height, at the same time taking into consideration any damp, oily or overheated materials which are liable to cause spontaneous combustion.

Grain sacks may be stacked two high, on end, in rows of three or more. Perhaps the biggest advantage of storing grain in sacks is that grain with a higher moisture content can be kept without deterioration. If the sacks are left open, grain with about 18 per cent moisture normally keeps for short periods and even higher figures of 18-20 per cent for temporary storage in cool conditions are sometimes satisfactory.

The main disadvantage of storing compound materials in bags is the high labour cost involved in handling and storing such a wide range of products in positions accessible to the processing plants. The large, single storey or the multi-floor warehouse as discussed in Chapter XXII under finished products, are the storage systems mainly in use.

PREPARATION OF CERTAIN MATERIALS FOR BULK INTAKE AND STORAGE

Mention must be made at this point that in compound mills certain raw materials have to be reduced in particle size before bulk handling and storage can be successfully attempted.

These materials include slab oil cakes, locust bean pods, malt culms, dried grains, lumpy and damaged meals. This work is performed either by cake breakers, pulverisers or smaller percussion grinders, and, although simple in itself, care is required, particularly in larger mills, in the choice and layout of machines to avoid unloading delays and double handling.

1. Processing of Slab Oil Cakes for Bulk Intake

Compound mills receive oil cake products from the seed-crushing industry in three forms; as slab cake, which is produced after the oil has been extracted from oil seeds by hydraulic presses; as expeller flakes, which are the residue of the expeller system, in which the oil is extracted by the pressure of a broken-threaded worm or screw, and as extracted meal, which is the product remaining from the solvent extraction process. To obtain oil cake meal, the compound miller has to kibble and grind the slabs but the expeller flakes only require grinding.

Expeller flakes and extracted meals are now coming on the market in increasing quantities and many compound millers buy them, partly because of the difficulty and expense of handling slabs. However, slabs may be unloaded satisfactorily from barges by derricks with the aid of cargo nets, and from road and rail wagons by friction hoist with a sling attached or sometimes by sack elevators or conveyors.

The storage of slabs and the double handling involved in taking them into store and out again may be avoided by installing a cake breaker in such a position that it can be fed direct from road or rail wagon or immediately after release from the derrick. The cake breaker, which must be capable of an output large enough to prevent undue increase in the unloading time and delay in the turn round of transport, discharges the kibbled cake on to a bulk conveyor running underneath along the quayside, or in inland mills to an elevator, feeding the storage or process bins ready for grinding. Slabs are usually 30 in. × 12 in. × ¾ in. in size, but vary according to the type of oil cake; they are broken into small pieces of ¾ in. to 1 in. diameter, which are suitable for bulk handling, storage and grinding.

2. Cake Breakers

There are several makes of cake breakers with capacities up to 30 tons per hour suitable either for fixing before a bucket intake elevator, or for use in the mill when the cakes are stored in slabs.

The Barron cake breaker is designed for use in bulk intake systems and may be mounted on rails so that it can be traversed along the quayside where the slab cakes and other materials are fed by hand direct from road or rail wagon. The kibbled materials then drop automatically into a drag conveyor underneath the machine and are conveyed to a bulk elevator for delivery to bulk storage or process bins. The machine consists of a feed hopper and one pair of special, heavy-duty, toothed rollers which are driven by a self contained 20 h.p. motor. It can deal with a capacity of up to 20 tons per hour, according to the type of cake being handled and the rate that the slabs can be fed from the vehicle.

Machines suitable for the small mill are manufactured by W. H. Nicholson & Sons and consist of one or two pairs of toothed rollers. The machine (Fig. 30) has two pairs of rollers, one above the other, the coarser pair being on top and the finer pair underneath. One roller in each pair is adjustable and, if finer kibbling is required, a curved plate, known as a ‘ concave ’, may be fitted underneath one of the lower rollers. The broken cake is then carried round between the roll and ‘ concave ’ and crushed a third time. This machine has a capacity of 30-40 cwt. per hour and consumes 4 h.p.

Another Nicholson machine of useful capacity for the medium sized mill is the No. 9 W. It is 20 in. wide, kibbles 2-3 tons of cake per hour and consumes 6 h.p. Adjustable hoppers are supplied for different types of cakes and other materials. Rollers of hard steel, with specially tempered teeth, can be supplied for material likely to contain a large percentage of tramp iron and for other heavy work.

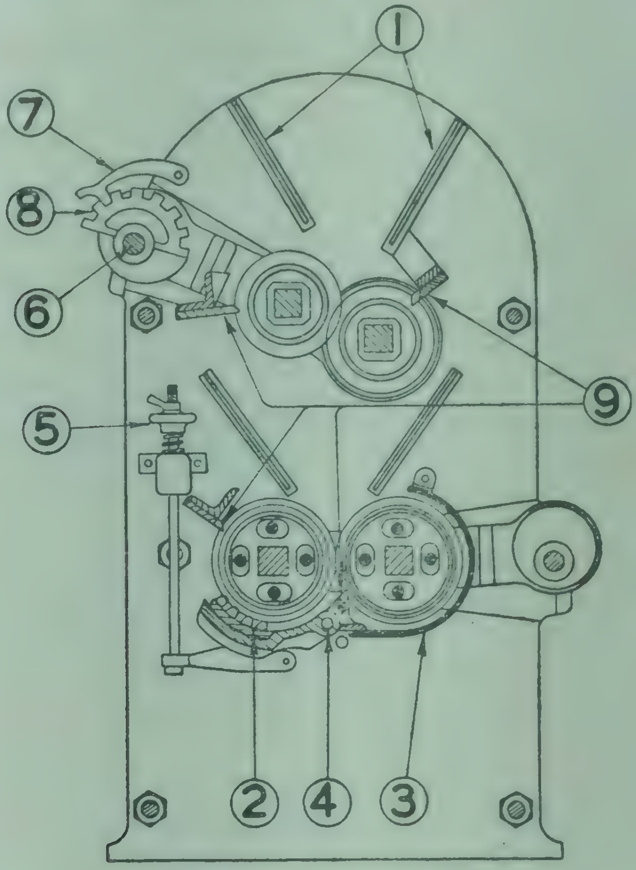


FIG. 30.—Small cake breaker—Nicholson type.

1. Guide plates. 2. Concave. 3. Curved plate. 4. Concave pivot rod. 5. Handwheel operating concave. 6. Shaft for eccentrics. 7. Locking catch. 8. Ratchet. 9. Scrapers.

The Flextooth Crusher (Fig. 31) made by British Jeffrey Diamond Ltd. is used in larger compound mills for kibbling slabs and other materials, and works on a different principle from the foregoing (Fig. 30). The machine has a totally enclosed rotor fitted with stellite tipped hammers, and may be driven by ' V ' ropes or flat belt. A wide feed opening situated directly above the rotor enables the hammers to effect a primary reduction while the material is still in suspension. A secondary reduction is made when the cake is carried round by the hammers and broken on the adjustable breaker plate. The kibbled cake is discharged through screen bars fitted in the bottom of the machine which are spaced to suit the type of cake being handled. Cake not reduced to the required size is carried round for further reduction.

Damage to the machine by the presence of tramp iron in the cake is safeguarded by a shear pin device on the driving pulley and by shock absorbing springs fitted to the breaker plate. The hammers are held in the crushing position by centrifugal force and, therefore, are free to swing back when striking hard materials. In addition a built-in metal trap with hinged covers is provided.

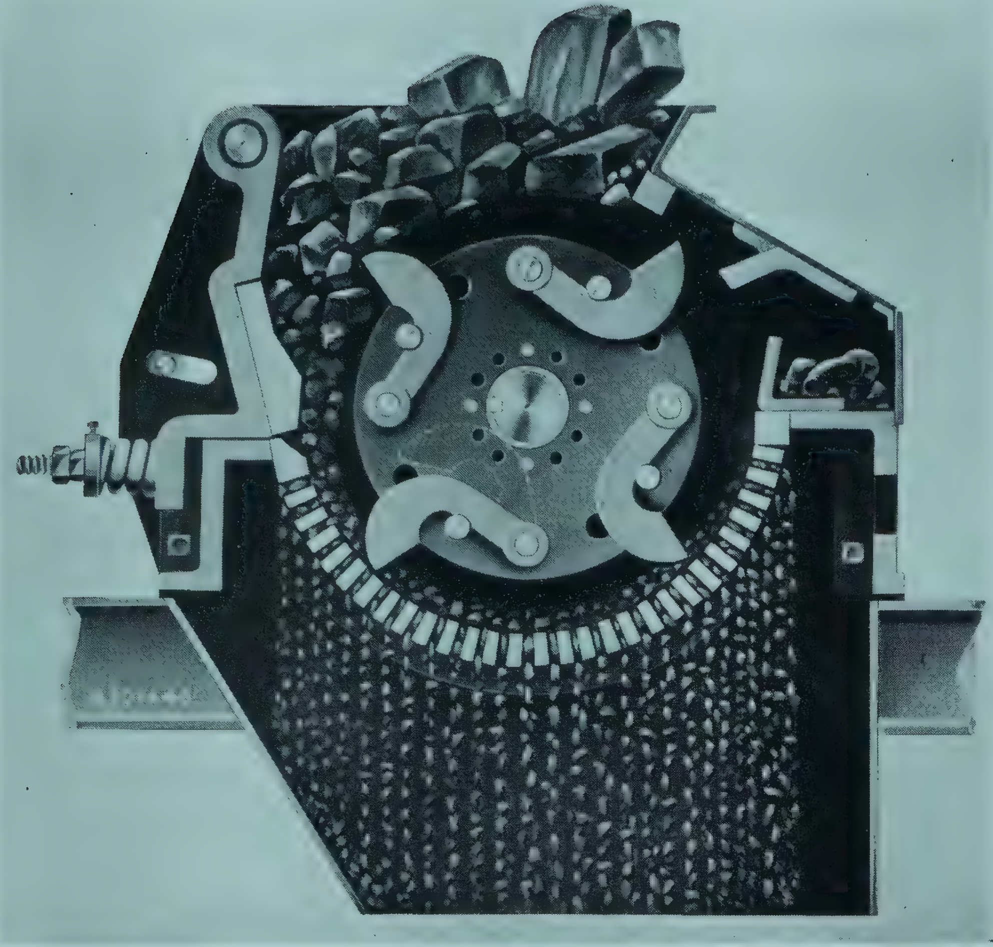


FIG. 31.—Flextooth crusher for heavy duty kibbling of oilcakes.

A popular size of machine is the 24 in. × 20 in. Crusher, which handles 10-15 tons per hour of 30 in. × 12 in. × $\frac{3}{4}$ in. slabs when driven at 750 r.p.m. by a 25 h.p. motor. A larger machine of 36 in. × 24 in. handles up to 30 tons per hour of thicker types of slab cake, such as Burma ground-nut cake measuring up to 12 in. × 6 in. × 6 in. or Argentine sunflower cake which is approximately 19 in. diam. × $1\frac{1}{3}$ in to 3 in. thick. For this duty the machine is driven at 900 r.p.m. by a 50 h.p. motor, the cakes being reduced to pieces of approximately 1 in. diameter.

Some large type hammer mills or pulverisers, as described in Chapter IX, are also suitable for kibbling slab oil cakes.

3. Processing of Locust Bean Pods, Malt Culms, Dried Grains and Linseed Straw for Bulk Storage

Locust bean pods require treatment before bulk handling because, although the thick long pods pass through bulk elevators, they cannot be satisfactorily stored in bulk form. Also, these pods stick in grinder feed gates and have, therefore, to be broken on cake breakers, which must have fine toothed rollers or the pods will slip through untouched.

Other materials that are not free flowing, such as malt culms, dried grains and linseed straw, flow better from a bin if they are hand fed through small hoppers and ground on percussion grinders. Where grinding takes place after mixing, they are often tipped from bags into the drag conveyors feeding the mixers.

4. Processing of Lumpy and Damaged Meals for Bulk Storage

In compound mills, the various forms of meals sometimes arrive in a lumpy or otherwise damaged condition, either because of their initially high moisture content or because of delay or damage during transit from their point of origin and, consequently, they also have to be broken up by cake breakers or pulverisers before bulk handling. Examples are rice meal, tapioca meal and sometimes imported pollards and bran.

BULK INTAKE AND HANDLING MACHINERY

1. Bulk Elevators

Bulk elevators for intake and mill purposes are of five types :

(*a*) Bucket elevators—belt or chain types.
(*b*) Travelling ship elevators—bucket and link types.
(*c*) Pneumatic intake plants—suction type.
(*d*) Elevator-conveyors—bucket and link types.
(*e*) Pneumatic intake plants—blowing type.

(*a*) *Bucket Elevators*

(1) *Belt Type*. A bucket intake elevator for grain consists of a rubber or canvas belt fitted with steel buckets at intervals running vertically overhead and bottom pulleys inside a steel casing. Wooden casings, although used in mill elevators except for the boots and heads, are not so hard wearing for grain intake or, in fact, for most other compound milling purposes, particularly where steam is used. Steel casings are becoming more popular

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in compound mills. Sliding bearings should be incorporated in the bottom pulley so that the tightness of the band may be adjusted.

In smaller inland mills, grain usually arrives in sacks by road or rail wagons and is hand tipped direct into a hopper feeding a bucket intake elevator (Fig. 32). In larger port or inland mills, the sacks may be discharged on to a band or chain conveyor delivering to the bucket elevator so that a number of wagons may be drawn up alongside the conveyor and discharged at the same time. The conveyor may be arranged inside or outside the mill wall. In the former case, it is fed by a hopper and spout passing through the wall and, in the latter, by a raised hopper on an outside platform.

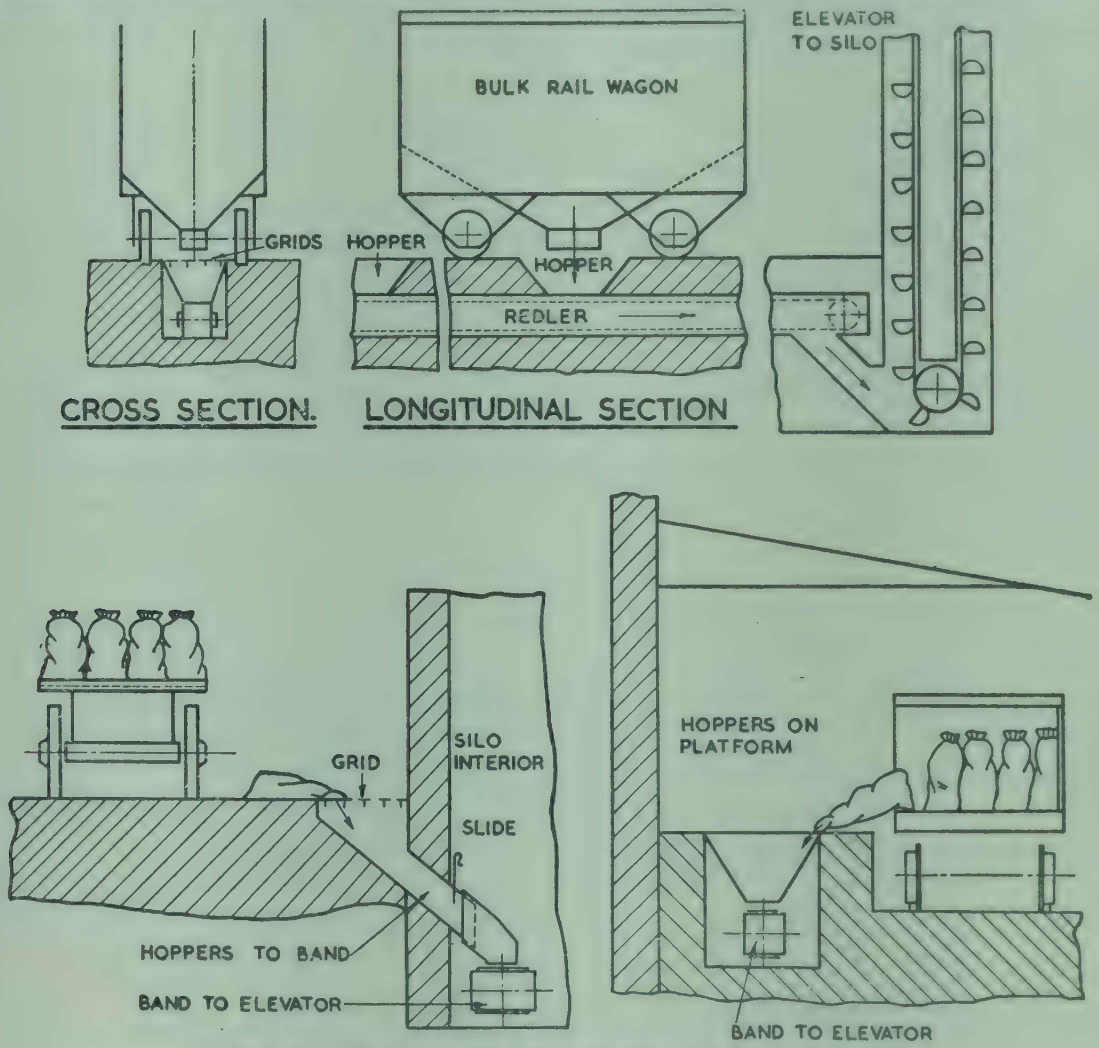

ELEVATOR TO SILO
BULK RAIL WAGON
GRIDS
HOPPER
HOPPER
REDLER
CROSS SECTION.
LONGITUDINAL SECTION
GRID
SILO INTERIOR
SLIDE
HOPPERS TO BAND
BAND TO ELEVATOR
HOPPERS ON PLATFORM
BAND TO ELEVATOR

FIG. 32.—Sack and bulk intake of grain from wagons.

Bucket elevators may also be used when the grain arrives by bulk rail or road wagons (Fig. 32). The wagon or wagons, fitted with slides underneath, may be run directly over a hopper or series of hoppers situated above a single band or chain conveyor delivering to the bucket elevator.

Woven cotton elevator belts are used with dry and free-flowing grain or meal, but for damp materials a canvas belt with rubber covering on both sides is most suitable. The belts should be at least 1 in. wider than the buckets, and, similarly, the head and tail pulleys should be 1 in. wider than the belt. A 100-ton grain intake elevator would have a band about 14 in. wide, a head pulley about 3 ft. 6 in. in diameter and a boot pulley about 1 ft. 8 in. in diameter.

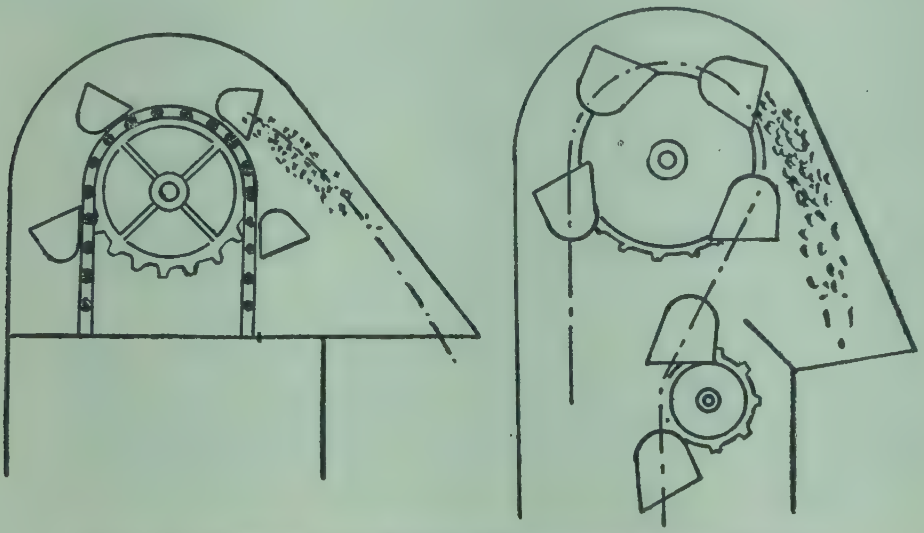
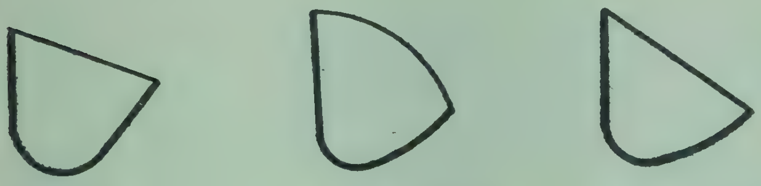
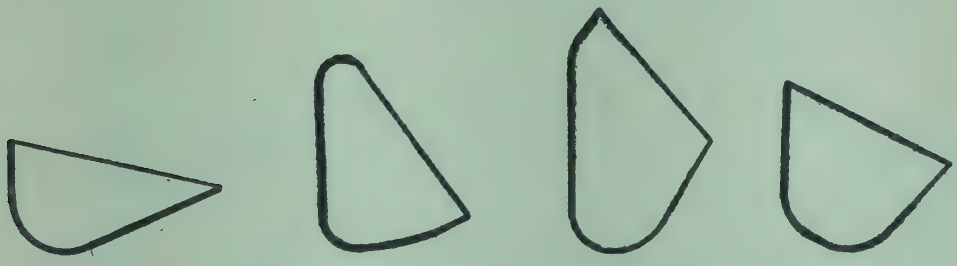


FIG. 33.—Standard and gravity discharge type bucket elevators.



FOR GRAIN FOR WET GRAIN FOR GENERAL USE.



FOR NON FREE-FLOWING MATERIALS. FOR HEAVY MATERIALS.

FIG. 34.—Shapes of elevator buckets.

(2) *Chain Type.* Chain type bucket elevators are similar to the belt type except that a single or double chain replaces the belt, and chain sprockets replace the pulleys. Belt and chain types may be used for either grain or meal, but the chain type is more satisfactory for wet or sticky materials.

Chain elevators are also suitable where low speeds in the neighbourhood of 100 ft. per minute are necessary, as, for example, the gentle handling of cubes to avoid breakage, and the handling of light materials which are liable to spread dust. High speeds have the disadvantage of causing a draught from the rapidly moving buckets, which tend to retard the feed into the elevator. On the other hand, low speeds necessitate much larger buckets for a given capacity and are not suitable for many compound materials which flow badly from the discharge point.

Chain elevators have the advantage that an improved type of discharge which is suitable for sticky and non-free running materials may be used. This is known as the gravity or perfect type discharge, in which the return side of the chain is guided under the head sprocket for a short distance by an idler sprocket, thus allowing the full effect of gravity to assist the delivery of the buckets. Owing to the slow speed, the discharge is gentle, which is an important factor in reducing breakage. Fig. 33 shows a gravity discharge elevator and, for comparison, one of the standard type.

Elevator buckets are of various shapes to deal with different materials (Fig. 34).

The capacity of a bucket elevator may be calculated as follows:

$$\frac{\text{Bucket speed (ft./min.)} \times \text{Bucket capacity (pounds)}}{\text{Bucket pitch (ft.)}}$$

This formula gives the maximum capacity in pounds per minute but the actual working capacity will depend on operating conditions. Poor conditions and design reduce the efficiency.

As a rough guide the horse power required for an elevator is

$$\frac{\text{Pounds of stock per minute} \times \text{height raised}}{33{,}000}$$

This does not allow for friction or inertia in pulleys.

Standard bucket elevators are simple, cheap and have a low power consumption compared with travelling ship elevators and pneumatic plants. Intake elevators have capacities of from 10 to 200 tons per hour for grain, and mill elevators from about 1 to 40 tons per hour for processed materials.

(*b*) *Travelling Ship Elevators*

Travelling ship elevators are used for the bulk intake of grain from ships, but they are not as popular as pneumatic intake plants. They may consist of

(1) The bucket type.
(2) The link type.

(1) *The Bucket type* (Fig. 35) consists of an ordinary bucket elevator, which is inserted into the hold of the ship or barge. The elevator may travel along the quayside in order to empty each hold, or it may be fixed to the side of a building, in which case the ship or barge is moved. This type of elevator is also used in some cases for unloading bulk road or rail wagons.

A boom (Fig. 35), which can be moved out of the way when not in use, extends over the edge of the quay and lowers or raises the elevator, which is carried on a pivot.

The elevator leg is open at the boot to allow the grain to run into the buckets. In ship elevators, the boot pulley is small, to reduce the dredging

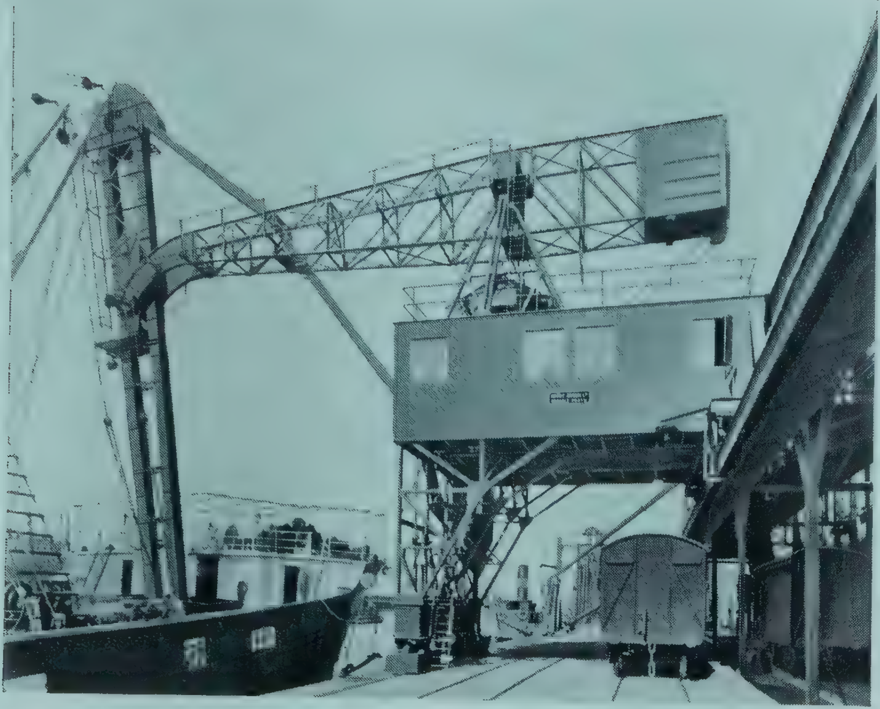


FIG. 35.—Travelling ship-elevator—bucket type.

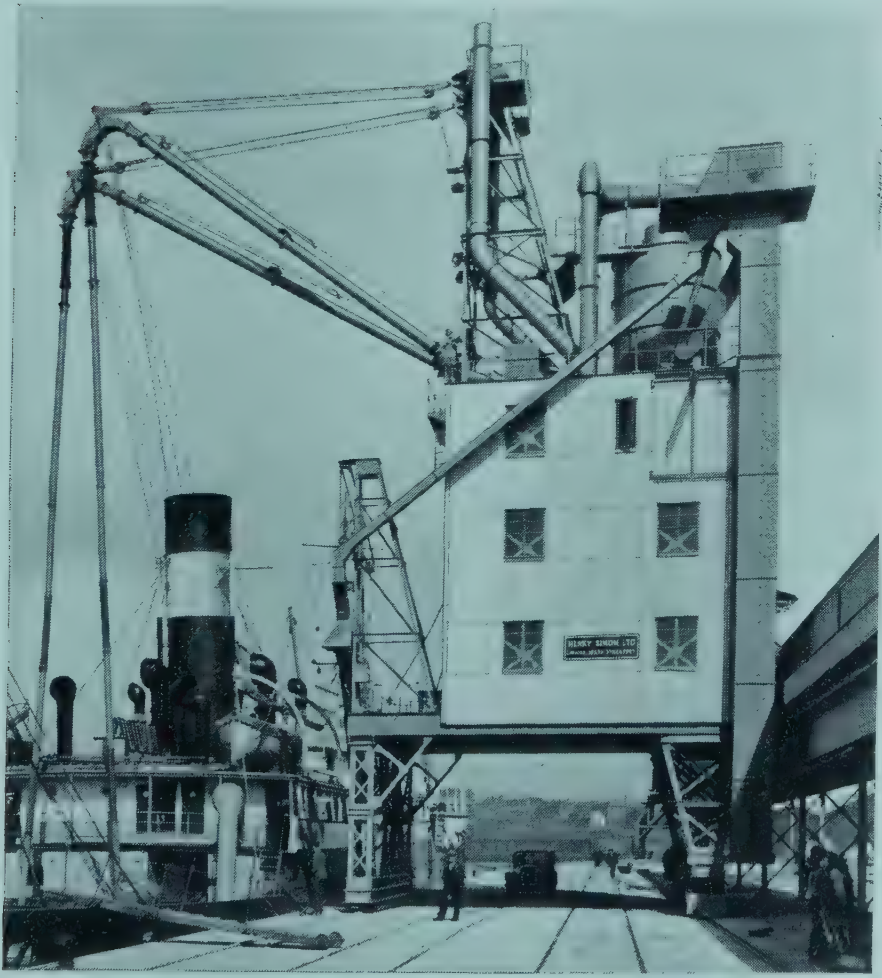

HENRY SIMON LTD

FIG. 36.—Pneumatic intake plant—suction type.

of the buckets through the material, and the head pulley is large to give a good delivery. The grain may be discharged from the elevator through telescopic spouting to a band or chain conveyor below the ground level of the quayside, which delivers to the receiving house, or it may be discharged to an overhead gantry. In the case of grain, ship elevators may be fitted with bands running at approximately 300 ft. per minute. Chains may be used for wet or oily materials.

(2) *The Redler Link type* varies in layout to suit particular requirements but is similar to the bucket type except that chains working on the *en masse* principle are used instead of buckets. (See elevator-conveyors and conveyors.)

(*c*) *Pneumatic Intake Plants—Suction Type*

Pneumatic Intake Plants (Fig. 36) for discharging bulk grain from ships and barges, are used in port mills. They consist essentially of five main parts :

(1) A reciprocating vacuum pump or rotary exhauster.
(2) Flexible pipes to nozzle, through which the grain is drawn from the hold to the receiver.
(3) A receiver in which the grain is separated from the air.
(4) A tipper or rotary seal through which the grain is discharged without breaking the vacuum.
(5) A dust collector, situated either inside or outside the receiver, which separates dust from the air so that clean air passes through the pump and is discharged to atmosphere.

The dust is sometimes returned to the grain for weighing convenience before being finally separated by the warehouse separators, but in smaller plants it may be sacked off.

These plants may be built either in travelling towers moving along the quay side or as fixtures. In the former case, the grain is discharged on to a band conveyor feeding direct to the receiver house as in the case of travelling bucket elevators. In the latter, all the equipment may be inside the mill, the suction pipe projecting through the wall and supported by a jib. This type of plant can also be used for bulk rail or road wagons.

The considerable advantages of pneumatic plants over travelling ship elevators may be summarised as follows :

(1) Minimum of trimming and easier accessibility to awkwardly disposed cargo, thereby saving labour costs.
(2) Cleaner atmosphere for men in the hold.
(3) Cooling and aeration of the grain.
(4) Small openings to the holds, enabling the plant to be worked in all weathers.
(5) A high average rate of intake can be maintained.
(6) Lower maintenance costs.

On the other hand, the disadvantages are the higher capital cost and the higher power consumption. A ship elevator averages only ½ h.p. per ton per hour of material.

These disadvantages are, however, more than offset by the superior efficiency of pneumatic plants since they can discharge a cargo at an average of about 80 per cent. of their maximum rated capacities as compared with an average of 50 per cent. of maximum for most bucket-type elevators.

(*d*) *Elevator-Conveyors—Bucket and Link Type*

(1) *Bucket Elevator-Conveyors.* The bucket elevator-conveyor is a development of the bucket chain elevator and consists of specially designed buckets attached to endless chains which run both vertically and horizontally over corner sprockets (Fig. 37). They may be used in compound mills for the bulk intake of meal or other material, which is fed into the bottom horizontal section of the buckets through a rotary or fan type feeder, and elevated and conveyed over a silo into which they are emptied. The speed of the buckets is only about 40 ft. per minute and, therefore, casing is not necessary.

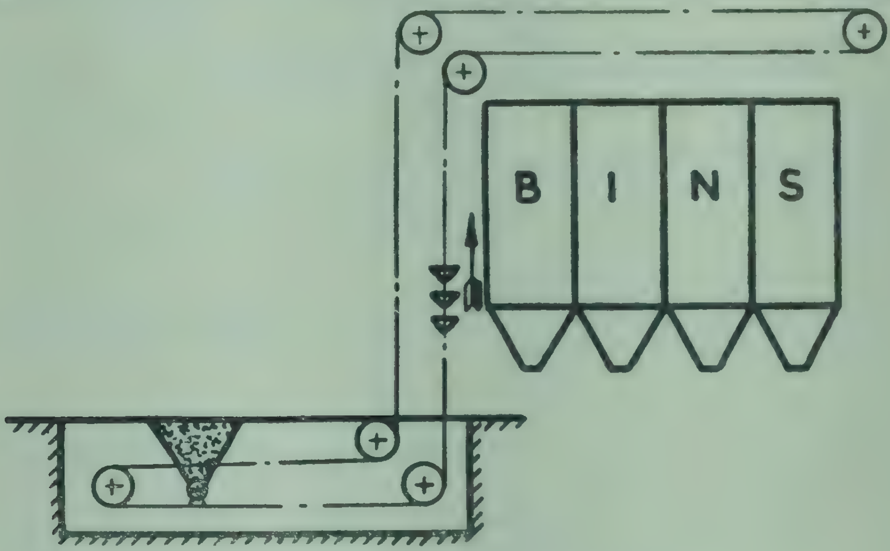


FIG. 37.—Bucket elevator-conveyor.

The speed of the rotary feeder is synchronised with the slow moving buckets so that the apertures or ports in the circumference of the feeders coincide with the passage of each bucket, thereby avoiding spillage between the buckets. The rotary feeders may be slowed down so that only every second, third or fourth bucket is filled by one feeder. In this way, a number of feeders may be set at different speeds so that each feeder delivers a different material into its own series of buckets, thus enabling several materials to be fed into one elevator conveyor at the same time. Each kind of material is delivered to its appropriate bin by an arrangement of cams fitted on the side of the buckets in conjunction with trippers in the conveyor tracks over each bin. Buckets containing one kind of material have their own series of cams, each tripper being adjustable into the path of any particular series and tipping the buckets of that series only into its own bin.

(2) *Link Elevator-Conveyors.* The Redler and the R.B. (Ready Built) Elevator-Conveyors may be used for bulk intake or mill purposes for meal or grain; they are developments of the Redler drag-link horizontal conveyor and, like the Redler ship elevator, use the *en masse* principle of conveying. Referring to Fig. 38 it will be noted that the shape of the link is different

from that used in the horizontal type (Fig. 42). The elevator type is specially designed to propel the material forward rather than to drag it through, and the link couplings enable the chain to turn from a horizontal to a vertical direction.

The material may be discharged from any intermediate point at the side of the elevator by removing part of the leg in addition to the normal discharge at the top of the elevator. The speed of approximately 50 ft. per minute and the Redler features of gentle handling and minimum space are similar to the types already mentioned.

(*e*) *Pneumatic Intake Plant—Blowing Type*

The use of pneumatic plants for the intake of meals, as distinct from suction plants for the intake of grain, is common in America because, in that country, meals arrive at the mill in bulk form and labour costs are higher. In this country, however, as meals arrive in bags, they are easily emptied into bulk elevators and conveyors of the bucket or link type which, although taking more labour, consume considerably less power than a pneumatic plant. Apart from one or two exceptions, therefore, pneumatic blowing plants are not at present used in this country for intake purposes, and practical experience on this subject is scarce. The modern practices of using pneumatic conveying from grinders and the advent of low pressure conveying systems are, however, providing valuable information (see Chapters XIX and XX).

Pneumatic systems for meal intake purposes are of the high pressure type and normally employ high speed turbo blowers in place of fans. The latter are of insufficient capacity for high speed intake plants.

A simple diagram (Fig. 39) illustrates a typical high pressure intake system. The meal is tipped direct from bulk lorry into a hopper large enough to take a full load. A rotary seal fitted in the bottom of the hopper feeds the meal into the air stream through a specially shaped tube, known as a 'venturi' inlet.

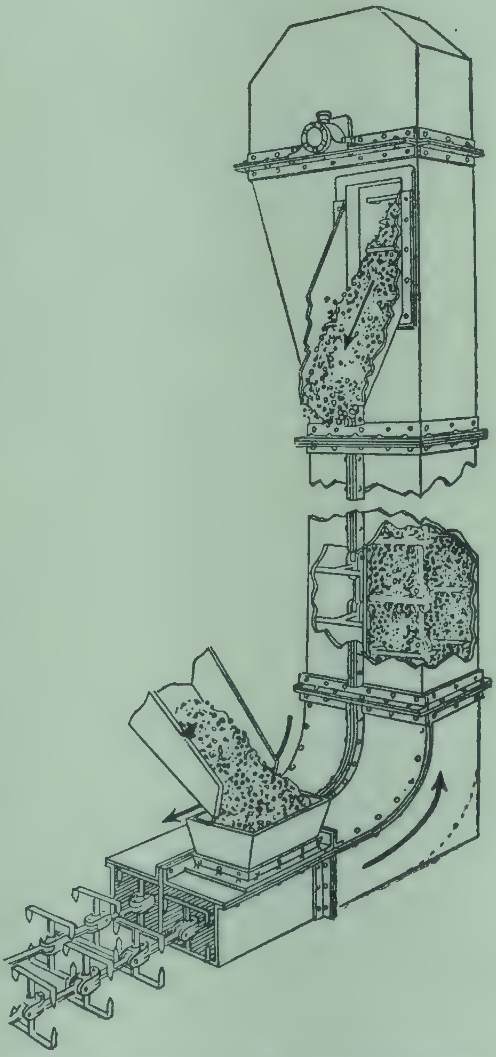


FIG. 38.—Redler link elevator-conveyor.

In the air stream, the meal is blown along the conveying line to the silo, the high pressure air being provided by means of a high speed turbo blower. The air is separated at the top of the silo and passes to a cyclone, which discharges to atmosphere, any meal remaining in the air being collected from the bottom of the cyclone.

The main factors, which have to be considered in a blowing system, are as follows:

(1) The conveying velocity.
(2) Ratio of air to material by weight, which determines the volume of air to be used.
(3) The resistance to flow of the air and material mixture in the conveying line.

The air velocity for conveying compound meals varies according to the density and particle size of the material and can only be satisfactorily determined by experiment. The velocity, which just supports the material in suspension, is known as the terminal velocity and it has been suggested by one authority that the operating velocity should be approximately two and a half times the terminal velocity. Average velocities for the various meals are in the neighbourhood of 3,500-5,000 ft. per minute depending on the nature of the meal.

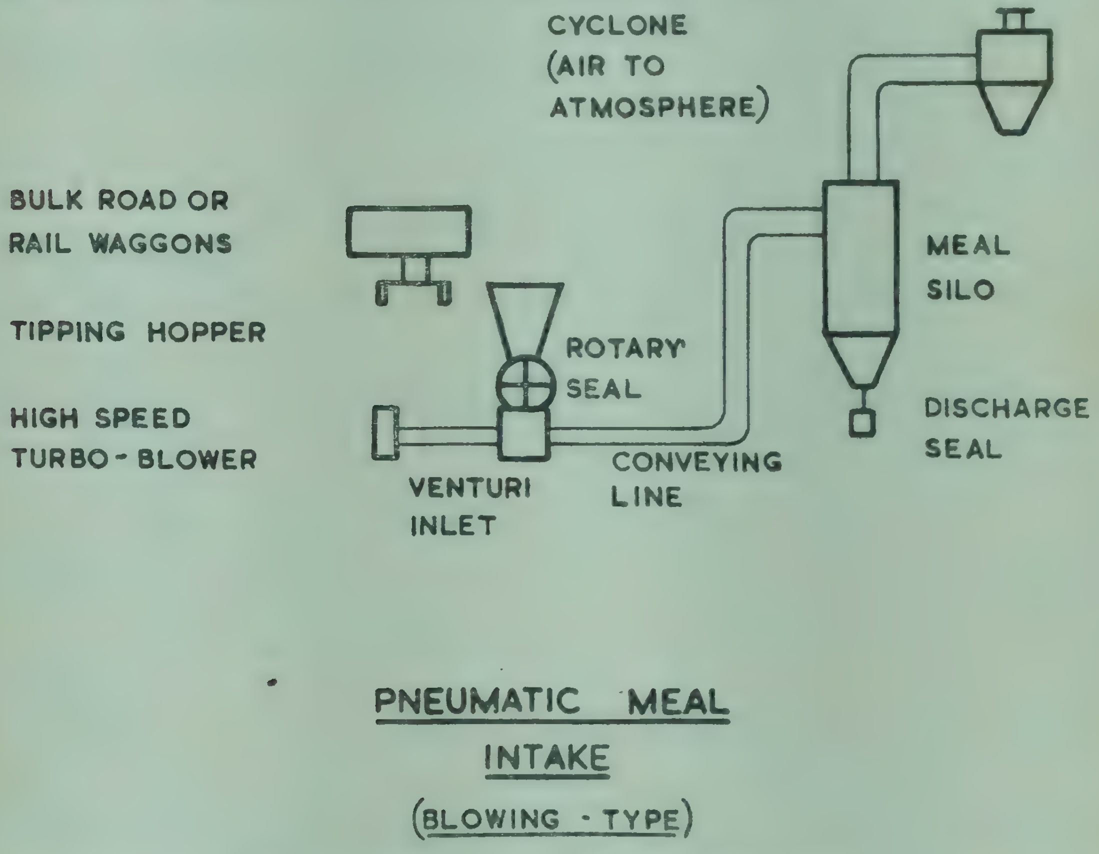

CYCLONE
(AIR TO
ATMOSPHERE)
BULK ROAD OR
RAIL WAGGONS
MEAL
SILO
TIPPING HOPPER
ROTARY
SEAL
HIGH SPEED
TURBO - BLOWER
DISCHARGE
SEAL
CONVEYING
LINE
VENTURI
INLET
PNEUMATIC MEAL
INTAKE
(BLOWING - TYPE)

FIG. 39.—Pneumatic meal intake—blowing type.

2. BULK CONVEYORS

Bulk conveyors are of four types:

(*a*) Band conveyors.
(*b*) Worm or screw conveyors.
(*c*) Drag chain conveyors.
(*d*) Scraper conveyors.

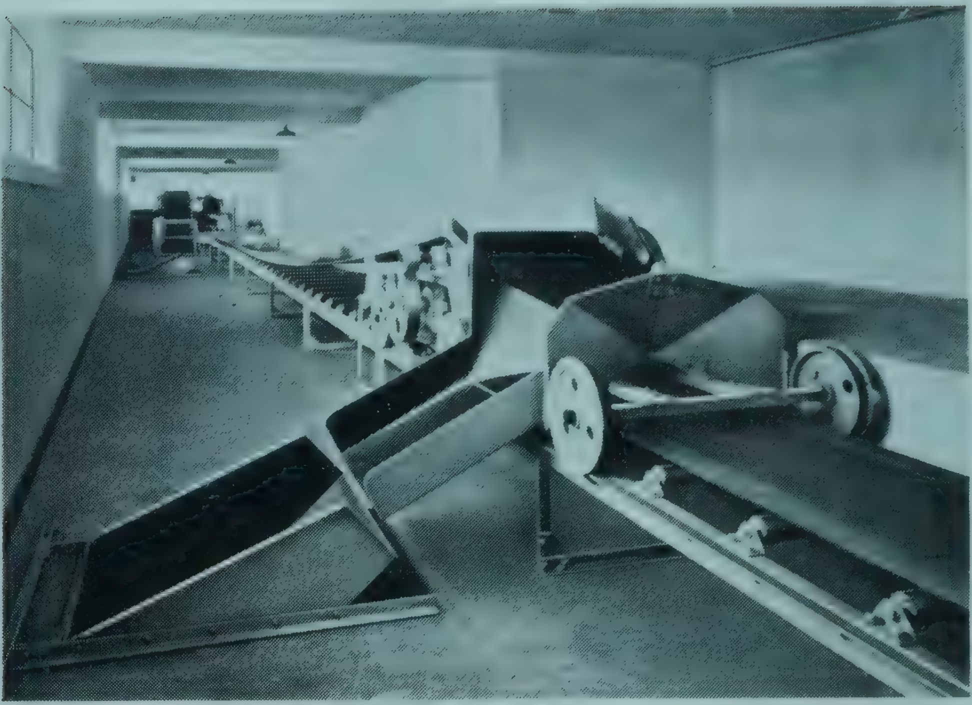


FIG. 40.—Sack band conveyor. *Note*. Type for bulk grain is troughed.

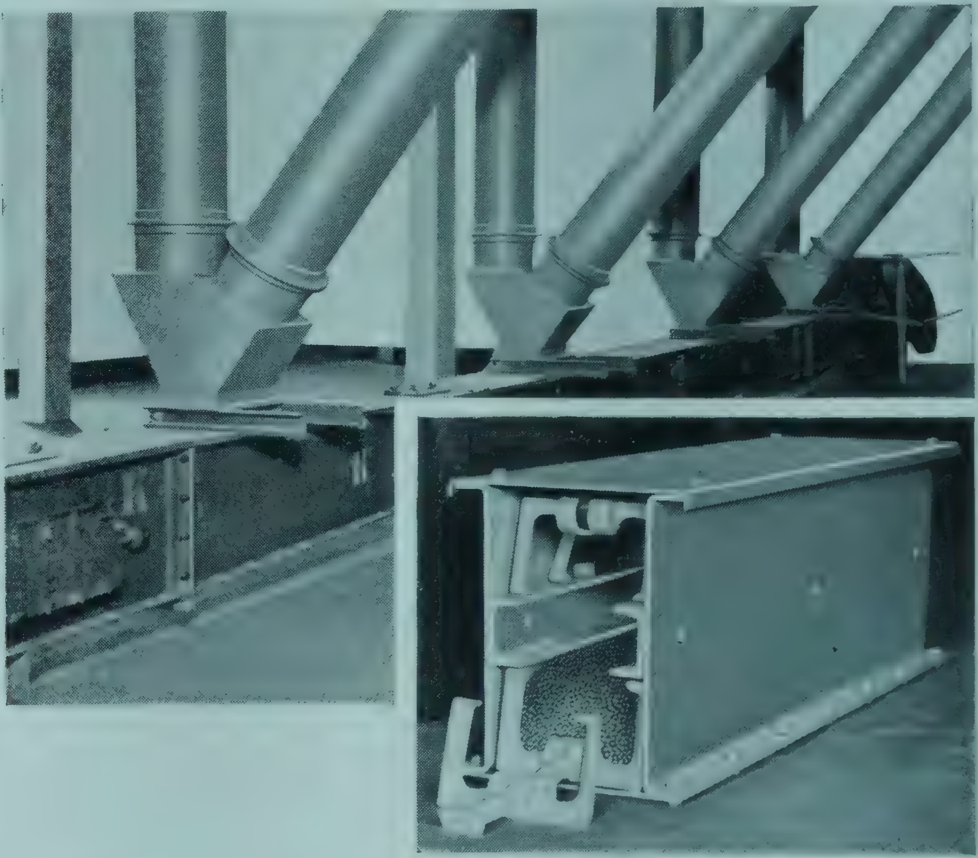


FIG. 42. —Redler drag link chain conveyor—horizontal type.

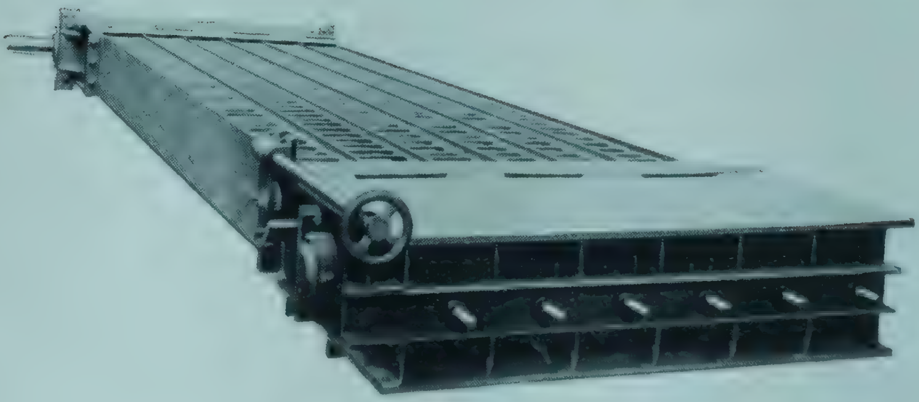


FIG. 43.—Redler bin discharger.

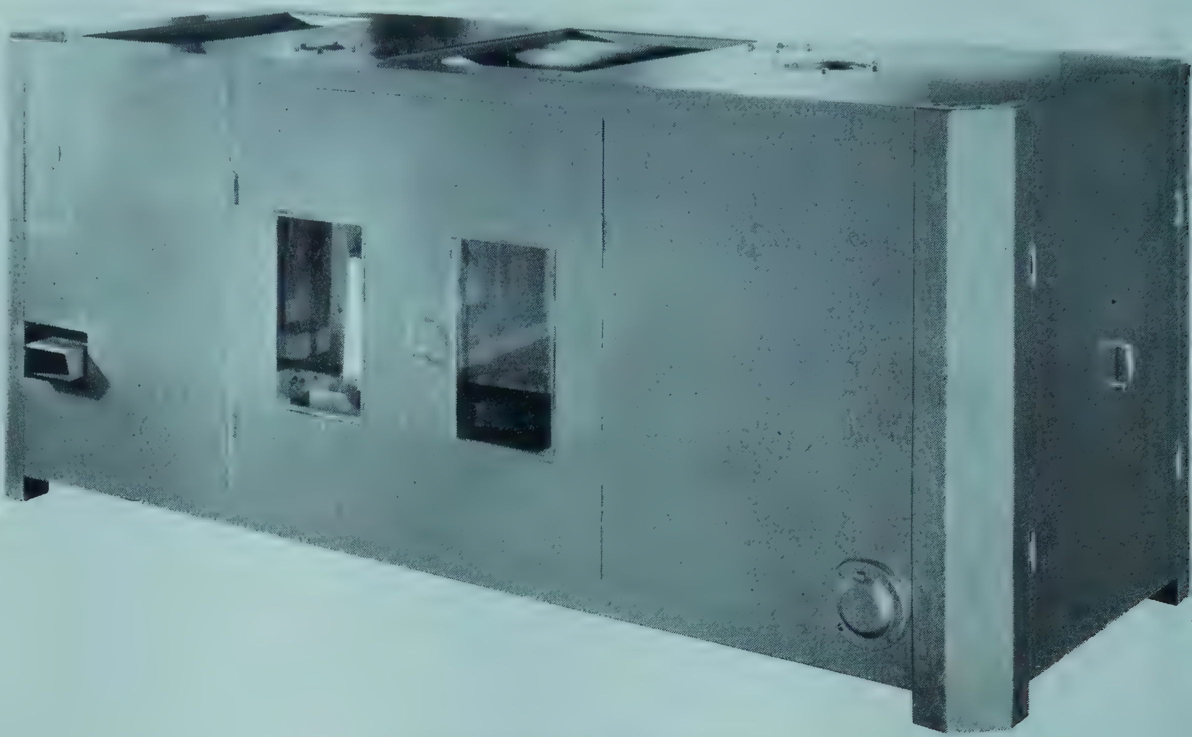


FIG. 73A.—The Rotosifter.

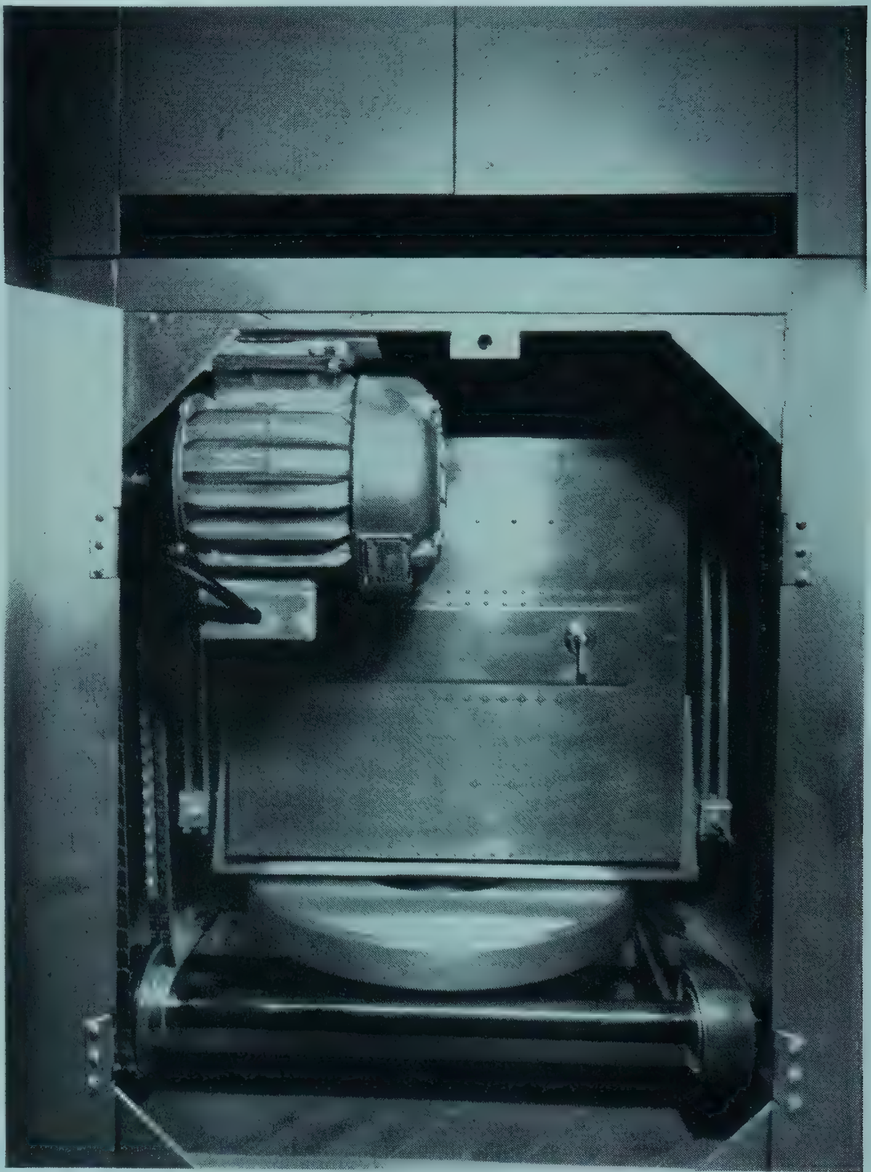


FIG. 73B.—A close-up view of the drive at the head of the Trigosifter.

(*a*) *Band Conveyors*

Large band conveyors consist of an endless belt running horizontally, or sometimes at a slight incline, over two pulleys at the extreme ends (Fig. 40). The belt is supported between the pulleys by small rollers, which may be flat or set at an angle at the sides, thereby making the upper part of the belt flat or troughed. The belt, which is made of balata or rubber and canvas, is usually driven by the head end pulley, the tail pulley being adjustable to keep the belt taut.

A throw-off carriage, which may be hand or power operated, is used for diverting grain into bins; it consists of two pulleys, one above the other, a hood and a spout, and is fitted with wheels, which run on rails, at each side of the band. The band passes over the upper pulley and under the lower one and, when the grain reaches the upper pulley, it is thrown off into the hood and spout to any desired bin.

Smaller conveyors used in the mill proper are usually made of cotton webbing and are enclosed in a wooden casing, the upper part of the band being supported on a shelf. The pulley bearings are adjustable to take up belt stretch. The chief feature of band conveyors of this type, compared with worm conveyors, is their gentle handling action.

The Gardiner conveyor, made by Gardiner Conveyors Ltd., is constructed on the above lines except that the bands are made of textile impregnated with rubber and perforated with suitable holes. It works on the *en masse* principle and can be fed and discharged at any point by means of a special slide. If desired, the material can be evenly distributed to a number of machines at once.

(*b*) *Worm or Screw Conveyors*

Worm or screw conveyors are most commonly used for carrying grain or meal short distances : they consist of ' U ' shaped, wooden or metal troughs containing longitudinal revolving shafts fitted with spiral blades which move the material forward. The four standard types of blades (Fig. 41) are:

(1) Paddle.
(2) Crescent.
(3) Continuous full bladed.
(4) Continuous spiral ribbon.

Paddle and crescent blades are popular because they can be easily turned and made to convey forwards or backwards. The blades are bolted through a light, tubular shaft and, in compound mills, they are useful for breaking up lumpy meals and for giving a mixing effect as, for example, under a line of feeders in a continuous blending and mixing plant.

Continuous full bladed worms consist either of stamped steel blades riveted together or of blades welded to the shaft with or without being riveted. This type gives the most positive conveying action and is used for feed worms in machines and for wet or sticky materials. To prevent the accumulation of meal in case of blockage, it is, in some cases, necessary to provide an emergency outlet at the end of the conveyor, or a reverse blade at the delivery end after the last outlet.

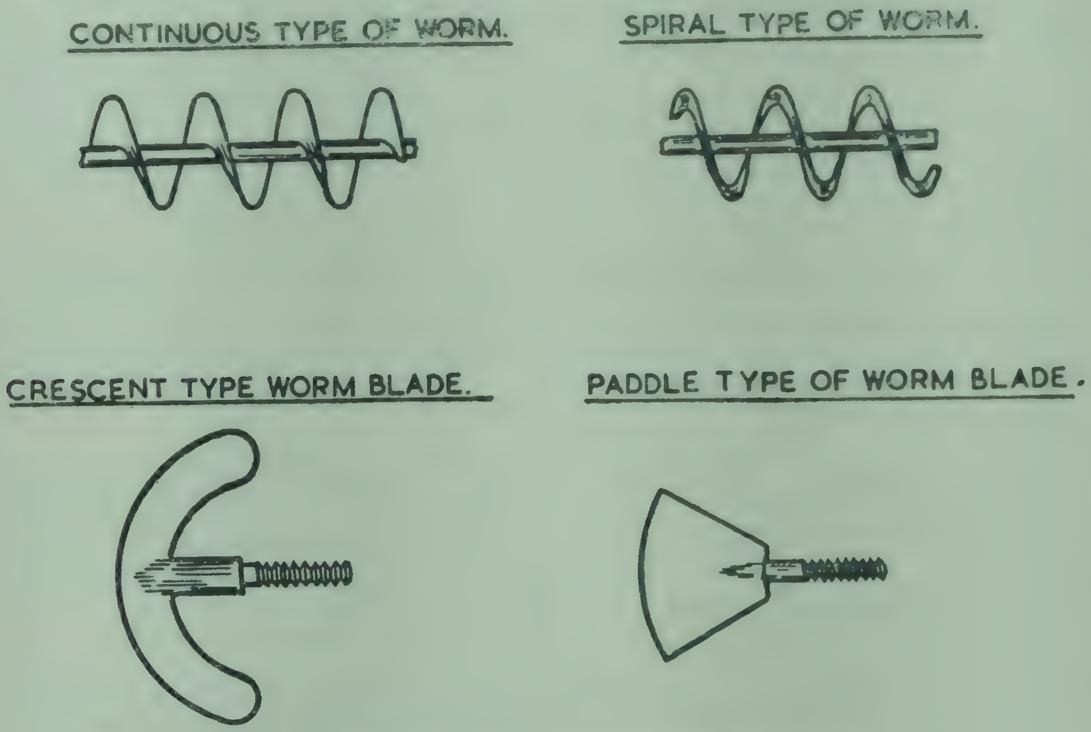


Fig. 41.—Types of blades used in worm conveyors.

The continuous spiral ribbon type is also suitable for wet and sticky materials and has the advantage of a central core, which has the same effect as the bending paddle and crescent blade, because, in the case of a choke, the worm will continue to rotate without damage to the blades.

In compound mills, a maximum speed of approximately 100 r.p.m. for a 6 in. worm, 80 r.p.m. for a 10 in. worm and 75 r.p.m. for a 14 in. worm, is usual.

(*c*) *Drag Chain Conveyors*

(1) *Link Type.* These are made by Redler Conveyors Ltd. and by Conveyors (Ready Built) Ltd. (Fig. 42), and consist ofendless chains of specially shaped links travelling over driving and adjustable tail sprockets in rectangular or circular casings. The upper chain is supported on guides fixed to the side of the casing, and the lower on the bottom of the casing. The material, which is fed through the top chain, forms a layer on the bottom of the conveyor and is dragged forward *en masse* by the lower chain. The conveyor is at full capacity when the depth of the mass is equal to the width of the chain.

If desired, a division plate may be inserted between the top and bottom chains so that material may be conveyed in either direction at the same time. In this case, the height of the conveyor casing will be rather more than double the width of the chain.

Standard Redler conveyors may be used on slight inclines up to about 20° but, over this figure, links, as used for elevator-conveyors, have to be fitted. Also, special couplings and linkage may be fitted to convey material round horizontal bends on single run circuits in the manner of a one way circular railway. These 'run-around' conveyors are useful for feeding a number of machines at the same time.

(2) *Bar Type*. Another type of drag-chain conveyor used in compound mills, either for intake purposes or in the mill as, for example, below a line of process bins when receiving material from travelling or fixed weighers, incorporates hard, wooden bars which are fixed to single or double chains in place of links. The conveyor works on the same principle as the link type and, when used under a line of bins, runs in a trough which holds the rush of feed from the tipping weigher.

Drag chain conveyors are noted for their gentle, self-cleaning and almost dustless action; they take about half the power of worm conveyors but slightly more than that of a band conveyor; they have little frictional resistance because the material is carried along at the same speed as the chain, which seldom exceeds 60 ft. per minute. These conveyors have a high capacity in relation to their size.

The carrying capacity may be calculated by using the formula $W^2 \times S$

where $W =$ width of chain in ft.
and $S =$ speed of chain in ft. per minute.

If the result is then multiplied by the weight per cubic ft. of the material being conveyed, the answer will be in pounds per ft. per minute.

(*d*) *Scraper Conveyors*

Scraper or creeper conveyors are not so widely used as the foregoing types. They are similar in design to a band conveyor, but instead of the material being carried along by the band, it is pushed along between the conveyor casing and the band by a number of wooden scrapers attached to the band.

In some types, the scrapers may be attached to a single or double chain running over sprocket wheels and guide plates. They travel at a very slow speed of about 40 ft. per minute and, consequently, may be used where there is a slow accumulation of material, as in exhaust trunks or expansion rooms. For compound milling purposes, they are more often used as short discharge conveyors or feeders from bins or certain machines.

BULK STORAGE

1. GRAIN STORAGE

The methods used in the bulk storage of grain in a compound mill are similar in principle to those in a flour mill; they are explained thoroughly in flour milling literature and, in this book, it is only intended to indicate the different aspects which apply to the compound miller.

A grain silo, or in America a grain elevator, in flour milling language, refers to a building separated from the main mill containing a nest of up to forty or more bins, including handling, weighing and rough cleaning equipment. In compound milling, however, the part played by grain is of relatively smaller importance and the silo is not nearly so elaborate; it usually consists of approximately six or eight bins, which are installed inside the main mill building, with little or no cleaning equipment; however, in some large mills, which bin meals and oil cakes, there may be about three times this number included in the silo, but in this country it is very rare that these meal bins are larger than process bins (see bulk meal storage).

Another difference in compound mills is the inferior quality of the grain, because usually only grain unfit for human consumption is used. Home grown grain is more likely to be damp and, although driers are sometimes used, greater care is necessary to see that the grain does not overheat in the silo. This necessitates more aeration and turning over from one bin to another and separate elevators and conveyors should be provided for this purpose; also, it is wise to install bin thermometers.

On the other hand, some types of foreign grain, such as Persian Barley, can be improved with additional moisture, which may be added before storage, by water wheel dampers. If grain is to be bulk stored for long periods without deterioration, the moisture content should not be more than 14 per cent but, with frequent turning over, it may be bulk stored at 16 per cent.

Separate grain silos are made of reinforced concrete because this type of building has low maintenance costs and concrete is proof against fire, vermin and climatic conditions. Also, concrete silos are quickly and conveniently erected and attractive in appearance. The most economical size is generally considered to be at least 60 ft. high by 20 ft. diameter but, on good natural foundations, larger sizes are not uncommon.

Concrete is sometimes easier to obtain than other materials, and it may be used for all types of bins for both grain and meal. Rough surfaces are undesirable but a smoother finish can be obtained by special treatment during casting. Steel hopper bottoms are frequently used.

In compound mills, steel is largely used for both grain and meal bins. It is especially favoured for the largest type of bulk storage silo which is usually found inside the main mill building. Steel plates can be erected comparatively easily and cheaply, and the low coefficient of friction of steel assists the flow of the material, thereby reducing the arching effect inside the bin above the hopper, which is one of the most difficult problems with meals that are not free flowing.

A disadvantage of steel is that it is liable to ' sweat ' with changes in atmospheric conditions and, owing to the fact that steel is a good heat conductor, these changes are quickly transferred to the material in the bin. This disadvantage can be obviated, however, if a gap of about 6 in. is arranged between bins so that a controlled current of air is circulated, although such a design increases the cost of construction.

In the past, timber was mainly used for small mill silos and smaller process bins throughout the mill because it was then by far the cheapest and easiest material for constructional purposes. This is still partly the case to-day but in compound mills steel is gradually becoming more popular because of its sounder construction, durability and other advantages already mentioned. It should be noted that timber bins are not vermin proof.

Small timber bins may consist simply of boarding and, when used for meal, they should be lined with sheet metal, particularly the hoppers, but silo bins are usually of laminated timber construction with asbestos or corrugated steel sheets arranged independently outside the timber walls, the roof being carried by the bins themselves. Alternatively, laminated timber bins may be built up inside a steel frame or brick structure with a clearance of up to approximately 1 ft. between the bins and the outside wall of the building. This allows for a certain sway which occurs when timber bins are being filled or emptied. Similarly, allowance must be made during erection for bins of this type to sink. The roof of this type of silo is supported independently of the outer walls.

2. MEAL STORAGE

Large meal silos, with one or two exceptions, are not used at present in this country, although they are common in America where meal is handled in bulk by large compressor plants (see page 57). Occasionally, as already described, when comparing bulk and bag systems, large open bulk bays with walls on three sides are used.

In this country, however, even in most large compound mills, meal is at present usually stored in relatively small bins which deliver direct to the process plant, the largest having a capacity of about 20 tons. The various meals, and other materials, except grain and oilcakes, are stored in the bags in which they are transported until there is space available in the bins. By careful management and regulation of deliveries and by feeding as much as possible direct into the bins from the lorries, it is, however, possible to reduce the amount of bag storage and double handling. Another advantage of process bins is that the ground products may be delivered direct from the grinders ready for blending with the unground products, thereby avoiding double handling. Otherwise, the ground products have to be bagged off and reweighed by hand as in batch plants.

Any system of bulk meal storage in this country is, therefore, apart from the one or two exceptions referred to, a combined system of bag and bulk storage. In this system, labour and bag storage space is saved, because the bagging and weighing of materials from the grinders is avoided, and a large proportion of the remaining materials is collected in a central position for the process plant direct from road and rail wagons and without double handling. Where all materials are ground after mixing, the layout of process bins is simplified, the grain and cake bins being arranged in the same range as the remaining materials. Further, the number of bins is reduced because none are required for ground products.

The main problems in connection with bulk meal storage arise from three causes :

(*a*) The difficulties of inducing certain meals of a sticky, non free-flowing character to flow from bins because of their tendency to pack or arch above the hopper.
(*b*) Risk of explosions through materials packing half way up the bin and then falling.
(*c*) Greater risk of overheating.

These problems are always present in the construction of all meal bins, but the larger the bin or silo and the longer the meal remains static in the bin, the greater they become. The easiest flowing meals, such as maize meal, will flow without difficulty from a 20-ton bin with a reasonable bin outlet construction, but the worst flowing meals, such as milk powder, will only flow from a comparatively small hopper and, even then, the flow may sometimes be irregular. Many of the latter are, therefore, handled and stored in bags.

Special care must be taken in the construction of meal bins to eliminate the non free-flowing characteristics of some compound materials as much as possible, and bins containing the worst flowing materials should be correspondingly reduced in size. In some cases, bin storage of these materials may be avoided by incorporating a pre-mixing system. In this system, the worst flowing materials are mixed before storage in batch mixers with those that are free flowing. The latter are known as ' carrier ' meals, because they carry or assist the flow of those that will not flow freely. (See ' Mixing Plants ', Chapter XII.)

The most efficient shape of bin for meals consists of two vertical and two sloping sides at an angle of 70°. The second vertical side may be conveniently formed by installing a partition down the centre of a large bin structure having one vertical and three sloping sides. The partition should finish about 2 ft. above the bin outlet and, for meal, the outlet should be substantially larger than for grain. Free flowing meals, such as maize and other granular meals will flow satisfactorily at flatter angles.

The arching or packing effect is caused by the weight of the meal in the bin, the greatest stress being at the top of the hopper. In large meal silos, the pressure can be relieved to some extent by fixing a number of steel girders through or across the bin in staggered fashion at various heights, but as a general rule any obstruction in the bin is a disadvantage and outweighs any advantage. Another method of relieving pressure of which experience is scarce, is to build the sides of the bin on the slant so that some of the weight is taken up on the sloping side. Owing to the scarcity of large meal silos in this country, practical experience of this problem is still limited.

BIN DISCHARGERS

In addition to the shape of hoppers and the use of ' carrier ' meals, the flow of meals from bins may be assisted by the use of internal mechanical dischargers or by vibrators fitted on the outside of the hoppers. When vibrators are installed, it is important to note that they should be switched off when the bins are not discharging, or, otherwise, the material will pack tighter then ever. Several well-known types of vibrators are on the market, an example being the one made by Lockers (Engineers) Ltd.

One of the simplest forms of discharger consists of an ordinary chain, which hangs down inside the bin over a sprocket. When the meal sticks, the chain is shaken by hand to break up the arch. Another principle employed is that of the simple worm feeder connected by an arm to an agitator, which breaks up the arch, as, for example, in the Nossen bin discharger manufactured by Henry Simon Ltd. and the Smith mixer manufactured by Thomas Robinson & Son Ltd. Henry Simon Ltd. also manufacture a vibrator feeder, known as the Velofeeder, as discussed on page 119, and a volumetric meal feeder having a specially designed wide inlet, which is used in mixing or process bins for blending materials on the continuous system, and is described on page 157. It is important to note that, when any type of feeder is fitted under a bin, the main weight of the material must not rest on the feeder itself or discharging troubles will arise.

Messrs. Redler Conveyors Ltd. manufacture a cone type bin discharger. In this machine, a central cone, fitted with feeder fingers, revolves slowly and sweeps over the entire base of the circular bin hopper discharging the material to one or more openings. A vane, attached to the apex of the cone by means of a universal joint, travels slowly round the inner surface of the bin, thereby breaking down any arching. If desired, a regulator can be fitted to feed measured quantities. These dischargers may be made to suit bin bottoms of 2 to 7 ft. in diameter.

Another type of Redler bin discharger (Fig. 43) employs special chain conveyors working side by side in a shallow metal box having a grid on its top surface. The top of the grid also forms the base of the bin, the material from the bin falling through the top flights of the conveyors to a platform from which the lower flights sweep it off to an outlet hopper.

The twin screw bin discharger is one of the most efficient and modern types to be developed by milling engineers. The Simon machine consists of two tapered variable-pitch worms running parallel to each other, and geared together in a double-troughed steel casing; the casing is bolted to the bottom of the bin hopper and is open at the top to permit the meal to enter. Part of the discharger projects beyond the side of the hopper and has an outlet underneath it while the top of the projecting portion is enclosed with a steel plate.

The discharger may be fitted either with an individual motor or a belt drive. When a motor is used, it is mounted on a bed-plate on the top of the discharger casing; it drives the discharge worms through flexible link rod couplings and a speed-reducing worm gear unit also mounted on the casing. The belt driven machine is fitted with a countershaft carried on the side of the discharger.

The speed of the discharger may be adjusted by altering the position of a variable throw eccentric incorporated in the worm gear unit; this unit is connected by the flexible link rod couplings to a double-action ratchet wheel on the discharger worm shaft. The unique motion transmitted to the worm by the double roller ratchet avoids " packing " the material and produces a smooth, even flow from the discharge outlet.

Chapter V

THE INTAKE AND STORAGE OF MOLASSES, COD LIVER OIL AND FISH SOLUBLES

MOLASSES

THE DRUM INTAKE SYSTEM

Millers, who buy molasses in relatively small quantities, sometimes handle it in drums. The drums may be emptied into a bulk storage tank, but more often they are stored in the warehouse until required for use; they may be fitted with a small hand pump which pumps the molasses to a service tank at the top of the mill; alternatively the drums may be hoisted to the tank.

THE BULK INTAKE SYSTEM

1. Intake

Molasses is almost always handled in bulk because, in this form, it is cheaper and less labour is required to handle it. In the bulk method, the molasses arrives at the mill by road, rail or barge tankers, which usually have a capacity of 10/13, 20 and 100/650 tons respectively.

Modern road tankers (Fig. 44) are fitted with inclined outlet chutes, as shown in photograph A, to discharge the molasses by gravity to mill storage tanks below ground level. Some tankers also have air compressors, as shown in photograph B, to pump the molasses to storage tanks on or above ground level. When discharging by gravity, a short, open chute is fitted between the outlet chute of the tanker and the storage tank, the chute passing through a hole in the outer mill wall. The minimum angle at which molasses will flow at this point is 30° but steeper slopes are beneficial. The compressors are worked by the engine and discharge the molasses through a flexible hose pipe to any height up to a maximum of 28 ft. The hose pipe is attached to the 4 in. pipe outlet, which is shown in photograph A, slightly above the gravity discharge outlet.

Rail tankers have no compressors but barges are fitted with pumps and steam coils to reduce the viscosity of the molasses.

2. Mill Storage Tanks

(*a*) *Construction*

Molasses storage tanks may be made of steel or concrete. An old boiler casing makes a good and cheap tank if one of sufficient size can be obtained. When road and rail tankers are used, the capacity of the storage tank should be at least 25 and 40 tons respectively to allow sufficient reserve for the process plant and space for a tanker's load. In port mills, where molasses is delivered by barge in 100/650 ton cargoes, the storage tank has to be much larger.

A good type of steel tank is the Braithwaite pressed steel tank, a section of which is shown in Fig. 47, which may be built up from standard unit

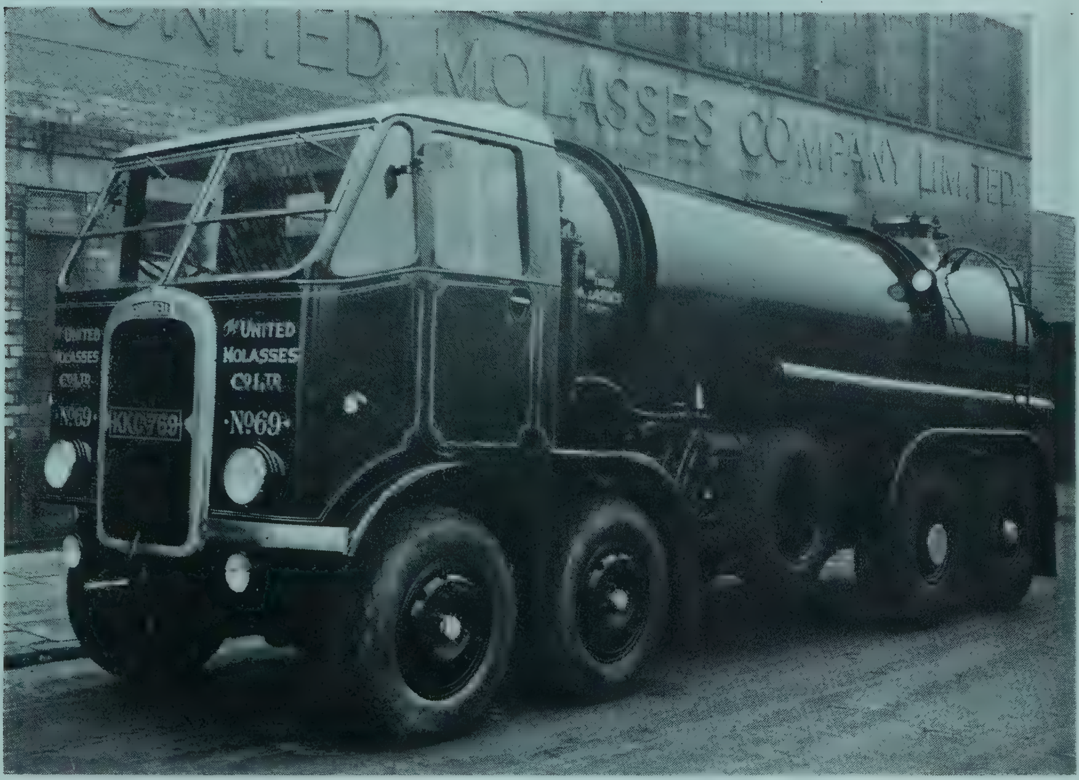

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FIG. 44A.—Molasses road tanker, showing compressor.

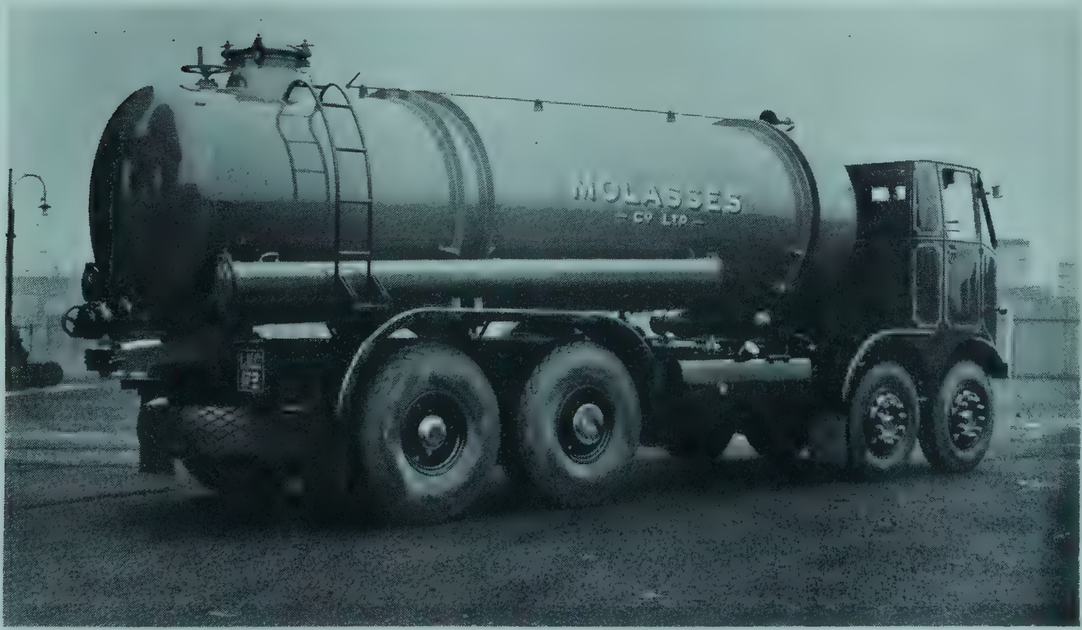
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FIG. 44B.—Molasses road tanker, showing gravity discharge.

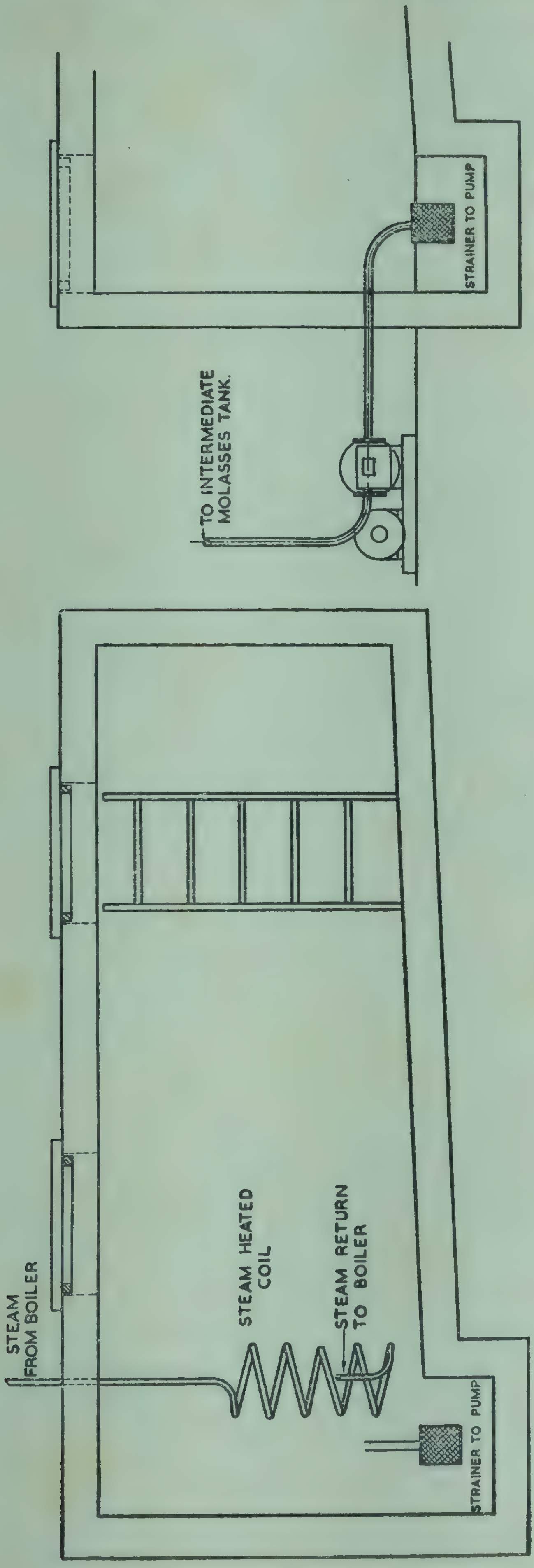

STRAINER TO PUMP
TO INTERMEDIATE MOLASSES TANK.
STEAM FROM BOILER
STEAM HEATED COIL
STEAM RETURN TO BOILER
STRAINER TO PUMP

FIG. 45.—Molasses mill storage tank.

plates and stays with a plastic jointing compound suitable for all temperatures and climates. At the present time, however, usually the simplest and cheapest method is to build the storage tank of concrete especially when below ground level. Fig. 45 shows a typical concrete tank of 25 tons capacity suitable for millers receiving molasses by road. Compound millers are sometimes hesitant about using concrete because of the fear that molasses may have a disintegrating effect on the surface. Provided, however, that the concrete is of the right quality, with a smooth surface, there is little danger.

The following proportions have been found to give a suitable concrete :

1 part cement
2 parts sand
2 parts gravel.

As an additional safeguard, the inside surface of the tank may be treated with silicate of soda, which fills up the pores of the concrete to a considerable depth. Cement contains a certain amount of lime and the sodium silicate combines with the calcium salts in the cement and forms a glassy surface. A special grade of silicate of soda is obtainable for treating concrete surfaces. It is a colourless liquid and must be kept in air-tight containers to prevent deterioration. Dilution by water is necessary to achieve penetration and generally 1 gallon of silicate of soda mixed with 4 gallons of water is sufficient to provide one coat for about 1,000 sq. ft. of surface. For a complete treatment three applications may be required and the solution in the second and third should be progressively stronger than in the first.

The concrete surface should be thoroughly cleaned before treatment. Then the solution may be poured on by means of a watering can and brushed evenly over the surface with a soft broom. After an interval of twenty-four hours, the surface should be washed down and allowed to dry before the next coat is applied.

(*b*) *Warming of Molasses in the Tank*

Some millers, particularly those who receive warm molasses from barge tankers containing steam coils, store and handle molasses at the same temperature at which it is delivered. In any case, it is not necessary to warm all the molasses in the mill storage tank; in most conditions when handling cold molasses, steam coils are installed at the outlet end of the tank, as shown in Fig. 45 and a steam pressure, sufficient only to warm the molasses to a suitable temperature for pumping to the service tank is used; the ideal pumping temperature is between 95°-100° F. and should not exceed 105° F. The steam pressure needed to obtain this temperature is normally only 10-15 lb. per sq. in. depending on the type of molasses in use. It should be noted that in Fig. 45 the bottom of the tank is sloped to the outlet to assist the flow of molasses to the pump.

When steam coils are used, care should be taken to see that the molasses does not become overheated through the use of higher pressures because, when molasses reaches a temperature of 140° F. the sugars begin to caramelise; it then bakes on the outside of the coils and forms into solid particles which pass into the pump and process plant and cause blockages. Molasses should not come in contact with live steam during storage because it is liable to boil and, if the tank is open, will overflow.

An efficient arrangement of the plant, which eliminates coils and saves steam consumption, is to install the tank adjacent to a boiler, either below or alongside it, and this may sometimes be done when the boiler house and tank are outside the main building and accessible to road, rail or water.

3. Handling between Storage and Service Tanks

On leaving the storage tank, molasses may be handled in two ways:

(*a*) By pumping direct to a service tank at the top of the mill in readiness for delivery by gravity to the compound plant.

(*b*) By pumping to a service tank from which the molasses is again pumped in a continuous circle through a main pipe back to the service tank with branch pipes feeding the various cubing machines in the compound plant.

A typical example of the first method, which is suitable for smaller mills, is as follows. In the service tank, which normally holds up to 150 gallons, the molasses is heated by steam coils from the pumping temperature of 90°-100° F. up to about 120° F. depending on the type of molasses. A rotary displacement pump with built-in 3 h.p. motor, which in this case is a Mono pump, type D4D, made by Mono Pumps Ltd., is placed alongside the storage tank and has an output of 1 ton per hour (160 gallons). For this output, the pump runs at 250 r.p.m. and, basing the maximum delivery distance at 100 ft. of piping and not more than 10 ft. of suction piping from the storage tank, all piping is 2½ in. in diameter. For an output of 2 tons per hour (320 gallons) for a similar distance, the same pump is suitable but in this case the pump should run at 450 r.p.m. with a 2½ in. delivery pipe and a 3 in. suction pipe. These figures are based on molasses having a viscosity of approximately 20,000 seconds, Redwoods No. 1 at the above temperature, but, if types of molasses with higher viscosities are to be handled, then the pump speed may require reducing or the pipe diameters increasing.

A valve should be inserted between the storage tank and the pump so that any blockage in the tank outlet may be cleared without the difficulty and unpleasantness of getting into the molasses tank. Also, if this valve is shut before the pump is stopped at the end of a run, the pump and the pipes between the tanks are emptied of molasses; this prevents the molasses becoming cold and sticky in the pump and pipes and avoids trouble when starting up.

An overflow pipe, slightly larger than the inlet pipe, is fitted from the service tank back to the storage tank to safeguard the former from overflowing or boiling over. Alternatively, a simple automatic float switch attached to a chain may be used to ensure that when the service tank is full or reaches any predetermined level, the pump from the storage tank is automatically cut out. When the tank empties to any pre-determined level, it may be re-started in the same way.

To ensure efficient pumping to the service tank, the molasses pump should be situated as near to the storage tank outlet as possible and piping should be larger in diameter than the pump outlet. For example, in the plant described above the pump outlet is $1\frac{1}{2}$ in. in diameter. For intake purposes and larger plants, pipes should be in the region of 4 in. in diameter. Wherever possible, sharp bends should be avoided because each bend is approximately equivalent to an extra 10 ft. of pumping distance in absorbing power. All molasses piping should be kept warm and this may be done efficiently by lagging the steam and molasses pipes together.

In the second method, which is more suitable for larger mills having a number of cubing machines, the service tank is installed in proximity to the storage tank on or below ground level and in such a position that the former is easily filled by gravity or pump. The molasses is then pumped from the service tank through a main pipe about 4 in. in diameter around the process plant and back to the tank, a series of small branch pipes with independent valves leading from the main pipe to the various machines. In this method the molasses is constantly in circulation and the temperature is kept constant more easily than in the first method.

4. VARIATION IN VISCOSITY

When handling and storing molasses, one of the most important aims is to keep its temperature constant at the various stages indicated above, because variation in this respect alters its viscosity and consequent rate of flow. When molasses is subsequently measured on a continuous basis into the compound ration this is particularly important and it is then beneficial to fit thermostatic control or at least some form of temperature recorder to the service tank.

Deliveries of molasses also vary considerably in viscosity irrespective of temperature, and, when adjusting the rate of flow, these variations must be taken into account. Typical examples of types of molasses in use with various viscosity figures at different temperatures based on Redwoods Seconds No. 1 are given below.

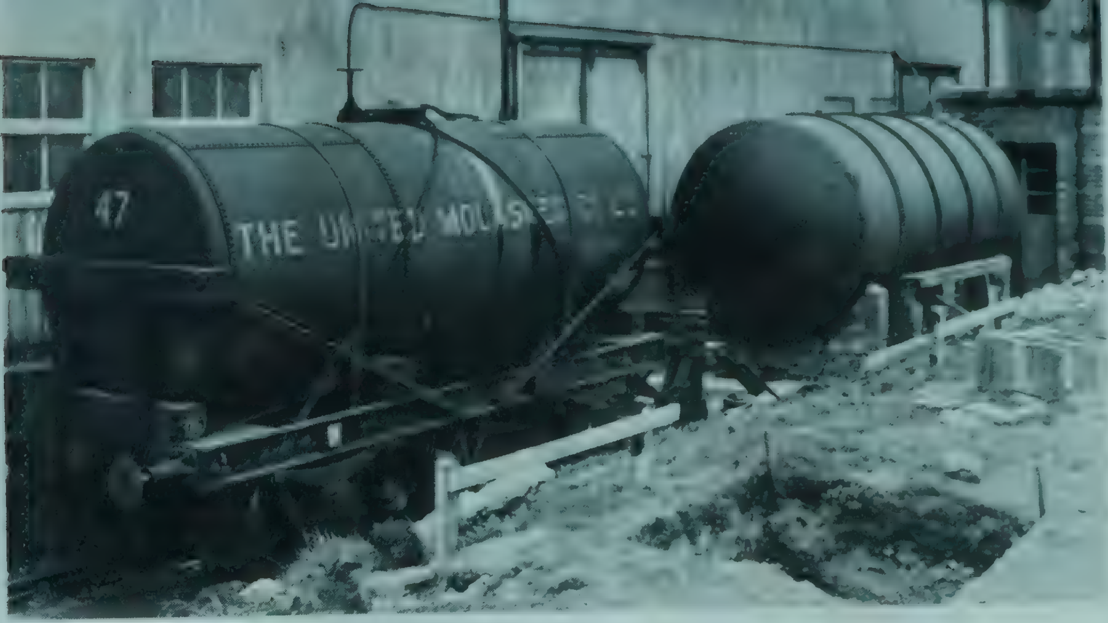
Redwoods Standards

The standard now taken is that of Rape Oil 50 cc. of which at 60° F. takes 535 seconds to flow through an orifice of given size. This is known as standard 100, and other oils when tested similarly take a longer or lesser period of time to flow, so that the comparison of time represents the relative viscosities. The higher the viscosity, the longer will be the time taken for equal flow.

	90° F. *Seconds*	60° F. *Seconds*
Cuban Blackstrap	30,000	140,000
Javan	50,000	150,000
West Indian	25,000	50,000

5. A TYPICAL BULK INTAKE PLANT

A typical rail intake plant belonging to Messrs. Carrs Flour Mills Ltd. and based on the first method described above is illustrated in Figs. 46 and 47. It has two steel storage tanks arranged on ground level, thus allowing plenty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THE UNITED MOLASSES CO LTD

FIG. 46.—Molasses rail tanker and storage tank.

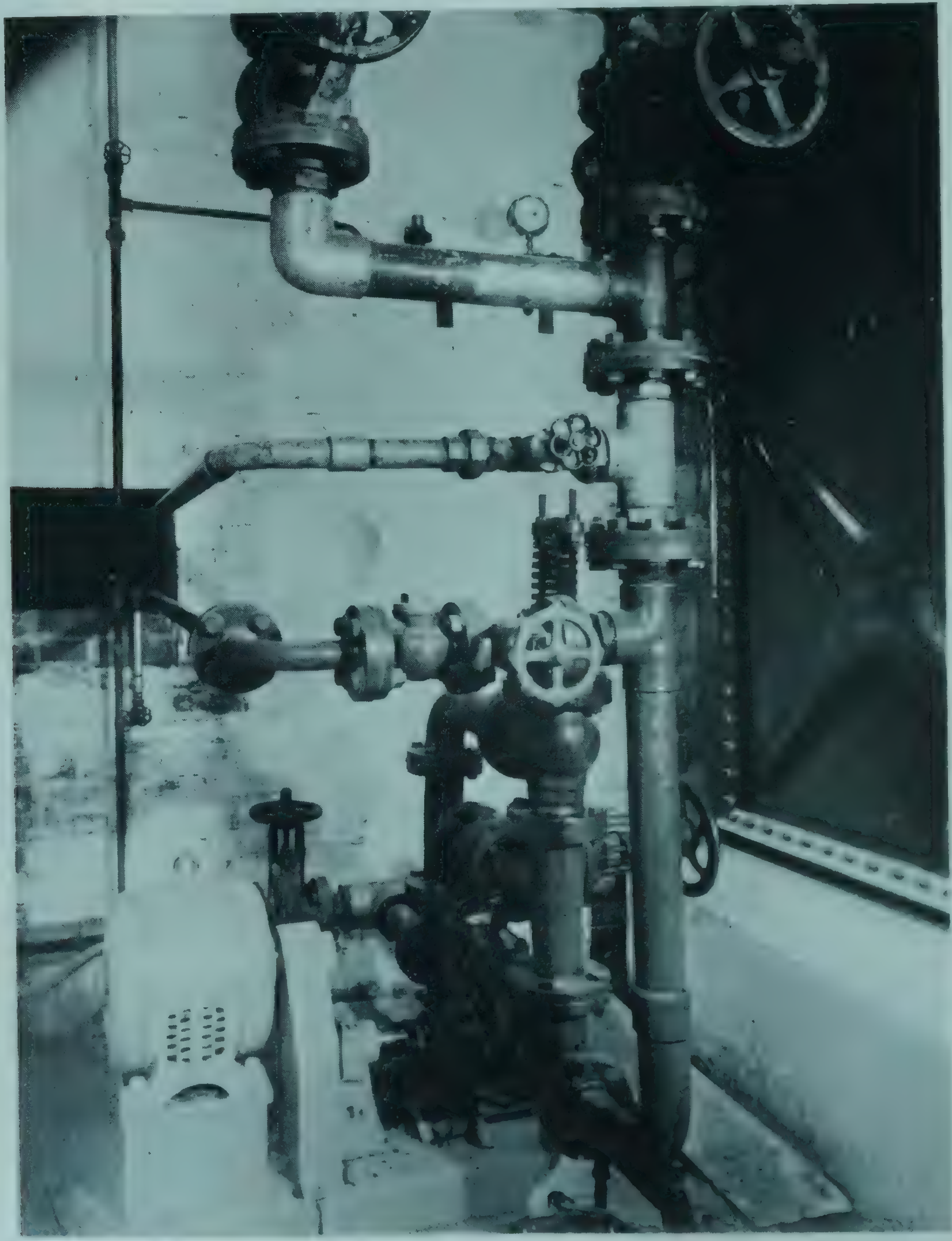


FIG. 47.—Molasses pump installation, showing section of steel plate storage tank.

of storage capacity for 20-ton rail tankers. One tank is outside the building adjacent to the unloading rail tanker and is of similar design to the tanker (Fig. 44) and the other, a section of which is shown in Fig. 47, is made up of Braithwaite steel plates.

The plant is designed on flexible lines and provides several alternative runs all passing through the mill pump (Fig. 47), which pumps the molasses from the rail tanker to either of the storage tanks, the service tank at the top of the mill or to drums. Provision is also made for the change over of molasses between the two storage tanks and for the filling of the service tank or drums from each storage tank. Steam coils are provided in the outlet of the inside storage tank.

SUMMARY OF CAPACITIES, TEMPERATURES, PRESSURES AND OTHER INFORMATION RELATING TO MOLASSES

Road tankers . .	10/13 tons capacity, fitted with gravity and some with compressor discharge.
Rail tankers . .	20 tons capacity, fitted with gravity discharge only.
Barge tankers . .	100/650 tons capacity, fitted with pumps.
Angle of flow between tanker and storage tank . . .	30° minimum.
Height of compressor discharge from tanker	28 ft.
Best pumping temperature . .	95°-100° F.

TYPICAL EXAMPLE OF HANDLING BETWEEN MILL STORAGE TANK AND SERVICE TANK (SMALL MILLS)

Steam pressure in storage tank (at outlet only) .	10-15 lb. sq. in.
Capacity of storage tank	25 tons road delivery (minimum). 40 tons rail delivery (minimum).
Capacity of service tank	80 or 160 gallons.
Steam pressure in service tank	10-15 lb. sq. in.
Type of pump . .	Mono Pump Type D4D or similar make.
Pump motor . .	3 h.p. built in.
Capacity of pump . .	1 ton per hour (160 gallons).
Speed of pump, maximum	250 r.p.m.
Pumping distance maximum . . .	100 ft.
Suction from storage tank	10 ft.
Size of piping . .	2½ in. diameter.
Viscosity of molasses .	20,000 seconds Redwoods No. 1.
Temperature in service tank	100°-120° F. depending on type of molasses.

COD LIVER OIL AND FISH SOLUBLES

1. Intake and Handling

Cod liver oil is not used as much as formerly owing to the advent of synthetic vitamins.

When cod liver oil is included in the compound it is only used in relatively small quantities of 1 or 2 per cent compared with the larger quantities of molasses of up to 10 per cent or more; it is bought in 45-gallon drums, in which it is usually stored until required for use ; it is never transported in tankers. The drums, although weighing about 5 cwt., may be hoisted to the top of the mill and fed by hand into a small service tank, where the oil flows by gravity to the process plant in the same way as molasses. Sometimes the drum itself is used as the service tank. A more economical arrangement is, however, to fit a small electric or hand pump with a flexible connection to the drum itself on the basement or ground floor to pump the oil by hand to the service tank at the top of the mill. In larger plants, the drums may be emptied into small steel or concrete storage tanks on or below ground level.

At Messrs. Carr's Flour Mills Ltd., an additional small, ground-level storage tank is used for emptying the drums of cod liver oil, although this is not shown in the illustrations. The oil is pumped by a separate pump direct to its own service tank at the top of the mill or, if desired, to either of the storage tanks normally used for molasses, or back to drums.

2. Storage and Treatment

Cod liver oil, unlike molasses, should always be stored in a relatively cool place and should not come into direct contact with steam, because excessive heat is liable to have an adverse effect on the valuable vitamin content of the oil. Cod liver oil is inclined to be sticky when cold and, when drums are used in cold weather, it is usually necessary to warm them to make the oil flow freely. This can be done quite simply by placing the drums over a small electric heater. Heating coils should not be used in storage or service tanks.

Fish solubles are mostly thicker than cod liver oil and consequently often need more warming but generally may be handled in a similar manner; some kinds have a particularly unpleasant odour and should be exposed, therefore, as little as possible to the atmosphere in the mill.

Chapter VI

WEIGHING AND CLEANING OF RAW MATERIALS

WEIGHING

RAW materials are weighed for two reasons :

(*a*) To check the quantity of material purchased.
(*b*) To enable the efficiency of the manufacturing processes in the mill to be calculated.

In compound milling, weighing is not usually considered necessary at the mill itself, except sometimes in the case of bulk grain, because, owing to present conditions of sale, the weights given by the port or other authorities have to be accepted. However, in cases where weighing is attempted at the mill, the only practical method of dealing with the variety of bagged materials is to use a weighbridge. Any attempt to employ automatic weighers of the type used for bulk grain is impracticable owing to the varying densities of the wide range of materials. The only alternative for the small miller is to check odd bags at random on platform scales.

The problems encountered with automatic intake weighers for grain in compound mills as distinct from flour mills, differ through the variation in weight per unit of volume of the various kinds of grain. In flour mills the weight per bushel is always approximately the same because the only grain in use is wheat, which does not vary appreciably. In compound mills, the difference in weight between barley, oats, maize and other grain means that the size of the weigher bucket must be sufficiently large to hold the same volume of the lightest grain being weighed. Otherwise the weights in the weigher box will have to be changed for each type of grain.

Automatic grain intake weighers vary in design and method of operation, but the majority work on the same main principle, which is that of the simple beam balance (Fig. 48). Many refinements are included to ensure continuous, speedy and accurate weighing, but briefly they consist of weigh buckets which weigh equal weights of grain. Machines are made with buckets to hold from approximately 28 lb. of grain to 3 tons. When the bucket is full, it tips automatically, the number of tips being recorded on an automatic counter, thus enabling the total weight of grain to be calculated. A hopper must be built below the weigher to take one or more complete charges from the bucket so that sufficient reserve is established to enable subsequent machines to work continuously.

The Simon Reform Weigher (Fig. 49) consists of a beam pivoted on knife edges, which are held in a frame. The weigh bucket is hung on knife edges and balanced by the weight box which is also hung on knife edges. Weights equal to the amount of grain to be weighed per discharge are placed in the weight box. The grain flows into the hopper which delivers to the weigh bucket via a feed gate. The grain is fed to the buckets as fast as possible, but in order to obtain accurate weighing, the filling of each bucket must be completed at a reduced speed. Therefore, at the point when the bucket begins to sink due to the weight of the grain, the feed inlet closes by means of a tray or gate. This gate only allows a dribble feed to pass into the bucket until the weight of the grain is equal to the weights in the box. As the beam passes the horizontal position it causes the dribble feed to stop immediately. The beam, continuing to pivot, releases a lever which allows a door on the bottom of the bucket to open and the grain is discharged. The beam then begins to pivot back under the pull of the weights, and, unless prevented, would cause the feed gate to re-open before all the grain has left the bucket. Consequently, some interlocking device has to be incorporated in order to prevent the bucket door and feed gate opening simultaneously.

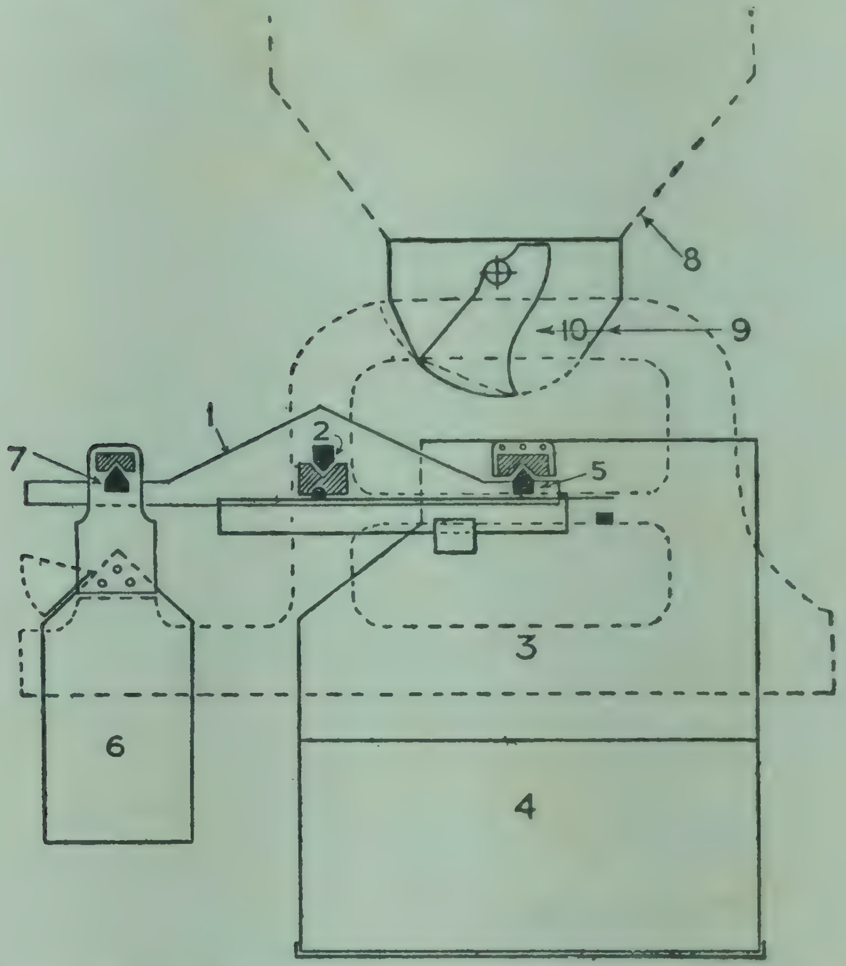
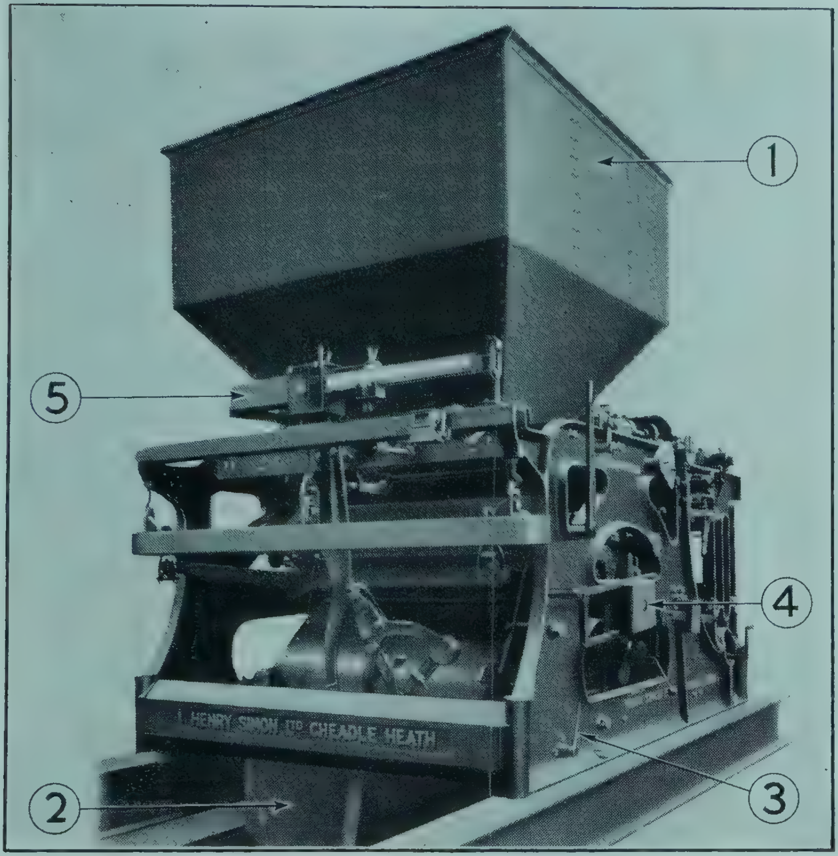


FIG. 48.—Principle of automatic grain intake weigher.
1. Beam. 2. Knife edges. 3. Frame. 4. Weigh bucket. 5. Knife edges. 6. Weight box. 7. Knife edges. 8. Hopper. 9. Feed gate. 10. Tray.

CLEANING

The operations involved in the cleaning of raw materials in compound mills consist almost solely of separating non-edible impurities, such as rubble, lumps, sticks, straws, strings and tramp iron, which are obviously liable to cause irregular processing and are dangerous to livestock. Cleaning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HENRY SIMON LTD CHEADLE HEATH
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FIG. 49.—Simon 'Reform' weigher.

1. Grain hopper. 2. Weigh bucket. 3. Handle for test weighing. 4. Compensatory device at cut-off of each weighment. 5. Residue weighing mechanism used at end of a run.

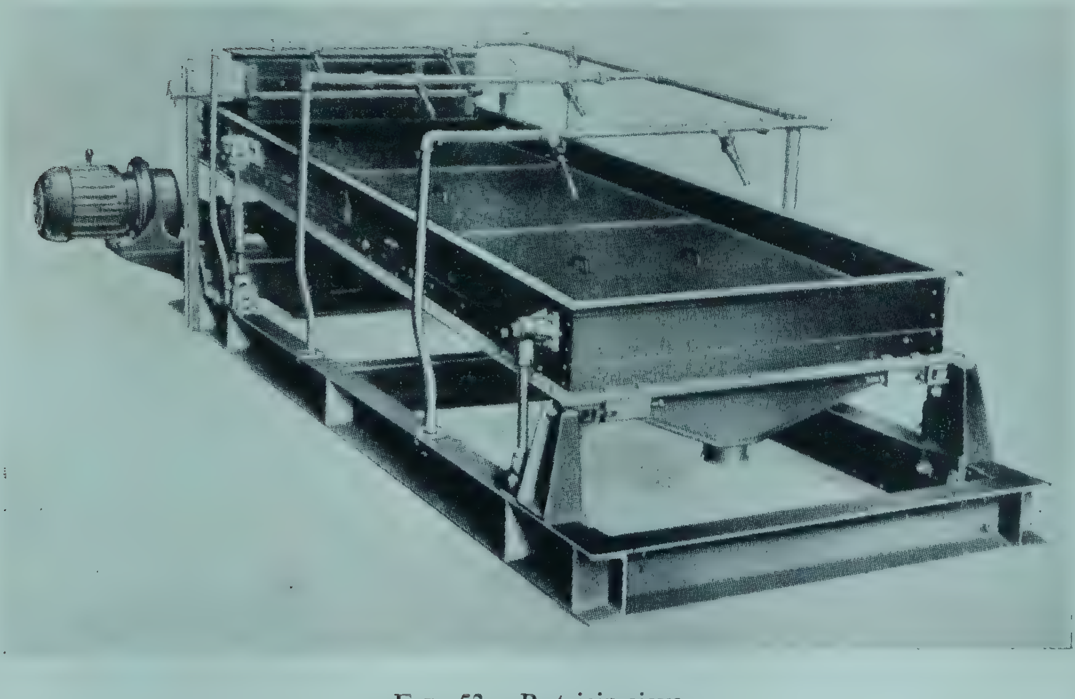


FIG. 53.—Rotricip sieve.

is, therefore, a simple matter compared with the more difficult problems of handling and storage.

When preparing grain for the compound ration it is unnecessary to separate edible impurities, such as foreign seeds and screenings, because seeds can be retained in the compound without detriment, and screenings are not harmful to livestock in small quantities. In addition, there is no object in cleaning the grain itself by such processes as washing, scouring and brushing as carried out in the modern flour mill. Some types of separators are, however, sometimes used for removing excessive dust to improve working conditions as well as for extracting non-edible impurities. When preparing meal for compounds, therefore, all that is necessary is the extraction of rubble, tramp iron, lumps and string, and where slab oil cakes are handled, only tramp iron has to be extracted after kibbling.

In the manufacture of ' straight ' products, the extraction of the major portion of the edible impurities is beneficial but even in these cases, the receiving or warehouse separator is usually all that is required. More efficient separations of foreign seeds and screenings by such machines as indented cylinders, disc separators and aspirators are not necessary except when cleaning grain for seed purposes. In a few cases, a simple form of grain washing may be carried out as, for example, in the manufacture of high quality meals on roller mill plants.

Therefore the cleaning of raw materials in compound mills may be considered under four separate headings :

(1) Grain cleaning for the compound ration.
(2) Grain cleaning for ' straight ' products.
(3) Meal cleaning for the compound ration.
(4) The extraction of tramp iron.

(1) GRAIN CLEANING FOR COMPOUNDS

Machines used for the extraction of large non-edible impurities from grain are :

(*a*) The fixed bar screen.
(*b*) The apex rubble separator.
(*c*) The scalperator.

(*a*) *The Fixed Bar Screen*

In many compound mills, the fixed bar screen is all that is used for the extraction of the largest foreign matter from grain, provided, of course, that efficient magnetic separators are installed to protect machines from the finer types of tramp iron which pass through the bar screen. The bar screen consists simply of bars fastened together in a strong frame so that the distance between them remains the same throughout their entire length. These bars are fixed at an incline immediately over a bulk grain hopper so that large objects are held back and slide to the bottom of the bars.

(*b*) *The Apex Rubble Separator*

This machine (Fig. 50) is made by the Millers Supply Co. and may be used in addition to or instead of the bar screen for the extraction of the worst of grain impurities; it consists of an endless band of coarse steel mesh mounted on head and tail pulleys. The impurities tail over the band as it travels over the end pulley and the grain, which passes through the band, is afterwards projected down a fixed inclined screen to separate sand. The standard machine is fitted with an aspirating leg for extracting dust, and although, as previously indicated, dust extraction is not essential from the feeding point of view, it improves working conditions.

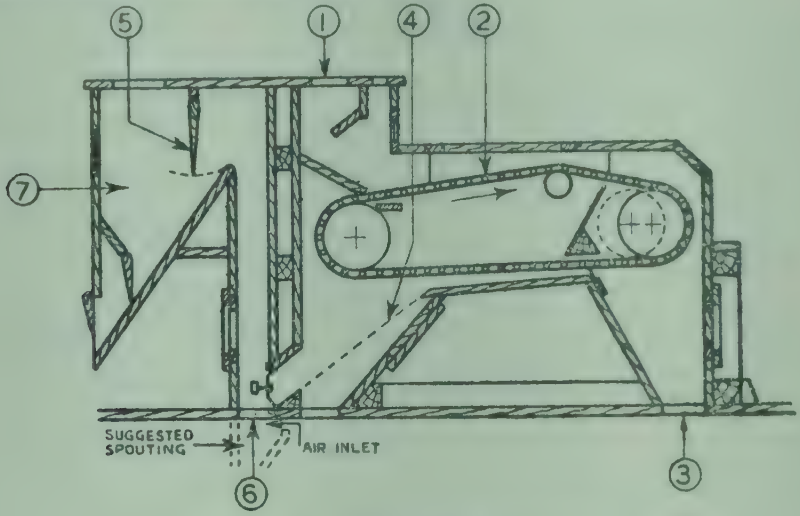


FIG. 50.—Apex rubble separator.
1. Feed spout. 2. Endless band. 3. Coarse impurities discharge. 4. Cleaned grain. 5. Valve controllers. 6. Grain discharge. 7. Aspirations.

(c) *The Scalperator*

The Scalperator (Fig. 51) is made by Henry Simon Ltd., and is used for the separation of large impurities from grain as an alternative to the Apex Rubble Separator; it consists essentially of a patented revolving wire cage containing curved, internal baffles. The grain, which is spread evenly throughout the length of the cage, passes through the mesh, the rubble being tailed over as the cage revolves. The unique feature of the machine is that the baffles retard the flow of the grain through the cage in such a way that there is always a mass of grain between the baffles and the wire mesh. Therefore, sticks, straws and other rubble cannot pass through and must tail over. A smaller cage is arranged on the rubble flow to recover any good grain that may escape over the first cage. As in the case of the Apex, the cleaned grain may be aspirated by a self-contained fan before being discharged from the machine.

(2) GRAIN CLEANING FOR ‘ STRAIGHTS ’

Machines used for the extraction of the coarsest edible impurities from grain are :

Receiving or Warehouse Separators

All types of receiving separators for preliminary cleaning purposes are based on the same working principles and consist of a series of oscillating sieves with head and tail aspirations. In the Simon machine (Fig. 52), a balanced feed plate spreads the grain evenly over a preliminary rubble sieve with large slotted steel perforations. The rubble is tailed over this sieve, the grain passing through on to the first main sieve. This has much finer perforations according to the type of grain being cleaned and overtails any impurities and foreign seeds larger than the grain. The grain then falls through this sieve on to the second main sieve, which has still finer perforations, and passes through small seeds, sand and other impurities, the grain tailing over.

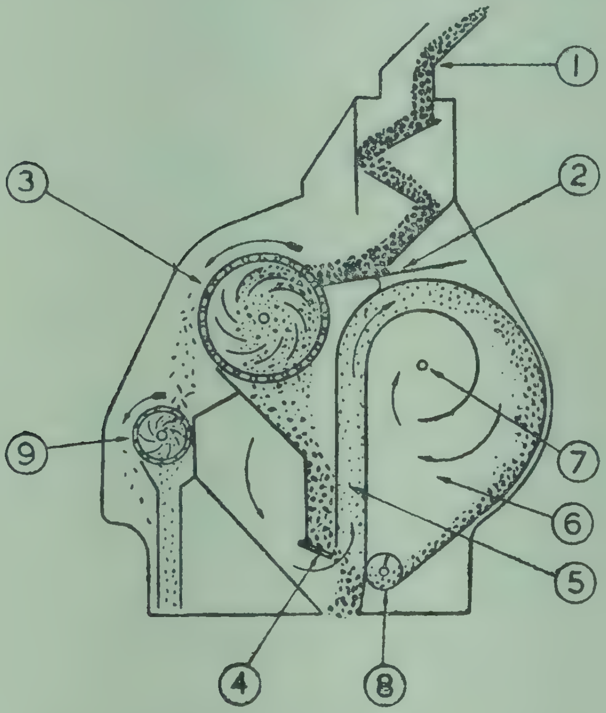


FIG. 51.—Scalperator.
1. Feed hopper. 2. Adjustable plate. 3. Squirrel cage scalping reel. 4. Seal gate. 5. Aspirating channel. 6. Settling chamber. 7. Fan. 8. Seal. 9. Retreatment reel.

The grain entering and leaving the machine is aspirated by a self-contained fan, the aspirations being drawn into expansion boxes and delivered from the machine by inclined channels situated on top of the sieves. The sieves are driven by eccentrics or by Juby drive and are clothed with perforated sheet metal, the meshes for different types of grain being given in the appendices.

(3) MEAL CLEANING FOR COMPOUNDS

Machines used for the extraction of coarse rubble, lumps and strings from meals are :

(*a*) Reels.
(*b*) Sieves.
(*c*) Brush sifters.
(*d*) Apex rubble separators for meals.

(*a*) *Reels*

Reels consist of large diameter cylinders of perforated sheet metal or wire which, in the case of Simon machines, revolve at 36 r.p.m. The cylinders are mounted on shafts with their axes inclined to the horizontal so that the material gradually works its way down the slopes. The most suitable cover for the preliminary cleaning of meal for compound purposes is No. 4 medium wire.

Reels are quite suitable and inexpensive for the separation of lumps and strings from meal for small intake plants but they have a limited capacity for larger plants. The capacity may be increased to some extent by elimination of the collecting worms in the hoppers and the substitution of double hoppers.

A disadvantage of reels in compound milling is that they take more space than sieves, and also, strings cling round the barrel shafts; they are cleaner than open sieves. Centrifugals are a development of reels and contain beaters, but they are not suitable for intake purposes and are only used occasionally in compound milling in grinding plants.

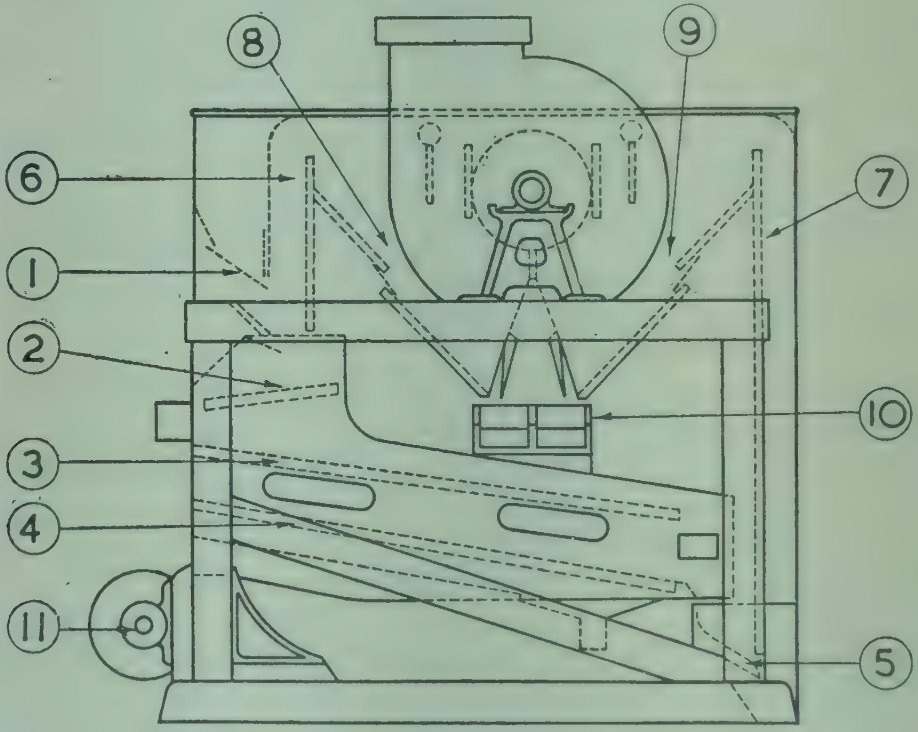


FIG. 52.—Receiving or warehouse separator.

1. Balanced feed gates. 2. Preliminary scalping sieve. 3. First main sieve. 4. Second main sieve. 5. Balanced plate. 6 and 7. Aspirating channels. 8 and 9. Settling chambers. 10. Inclined channels. 11. Shaft operating eccentric drive.

(*b*) *Sieves*

There are three types of sieve :

(1) The reciprocating sieve.
(2) The rotary sieve.
(3) The combined rotary and reciprocating sieve.

The reciprocating sieve consists of a simple screen driven by eccentrics or a Juby drive which imparts a reciprocating or oscillating motion; it is quite efficient for cleaning meals in small compound mills when fitted with a No. 4 medium wire mesh and enclosed, but has a smaller capacity than a reel.

The rotary sieve consists of a screen with a circular motion, usually suspended on hangers from the ceiling or sometimes supported from the floor; it is seldom used in compound milling.

The combined rotary and reciprocating sieve is the most suitable type for the cleaning of meals for intake purposes and has a much higher capacity than the foregoing types. This sieve has a rotary action at the head or drive end of the machine and a reciprocating action at the tail, and gives a large capacity per square foot of screen area; it is totally enclosed and is also used throughout the mill. An example is the Rotricip Sieve (Fig. 49 B) made by W. S. Barron & Son Ltd. A large size machine, when handling 10 tons per hour of meal, would be capable of passing approximately 70 per cent of the feed through a No. 12 mesh. (See Combined Sifters, pp. 95-98.)

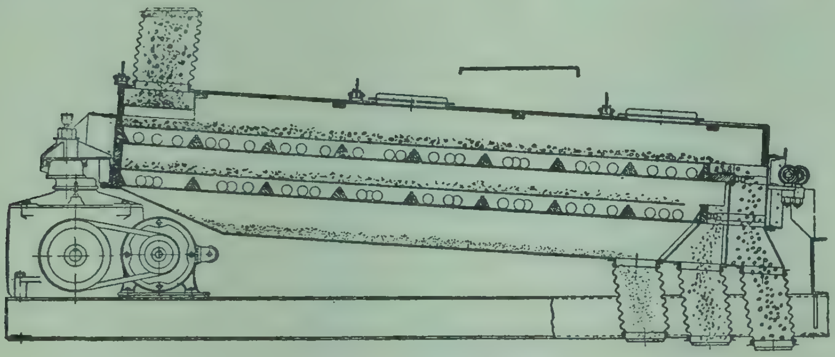


FIG. 54.—Rotex sieve.

Another example is the Rotex machine, made by Lockers (Engineers) Ltd. (Fig. 54). This machine may be fitted with as many as five screens, thereby giving six separations, but, for the cleaning purposes of the compounder, the single deck sieve is the most suitable. Rotex screens have a patented ball and bevel mesh cleaning system and are enclosed, thereby making them as clean and dust retaining as the reel. A further machine of this type is the Rexman sieve, made by Thos. Robinson & Son Ltd.

(*c*) *Brush Sifters*

These machines are sometimes used in the smaller compound plant because they take less space than reels and have a larger capacity than reciprocating sieves. The Barron machine (Fig. 55) consists briefly of an adjustable wire screen trough in which revolving spiral brushes push the material to be sifted against the screen, the throughs being collected by a worm conveyor underneath; the rubble overtails at the end of the machine.

(*d*) *Apex Rubble Separators for Meals*

This machine (Fig. 56) is similar in principle to that used for grain except that the aspirating section, which is not required for meals, is dispensed with. Also the meal separator has a special feeding device and a method of agitating the chain belt to ensure that no meal is carried over. The makers claim that this machine is particularly suitable for extracting string, labels and other foreign matter from meals.

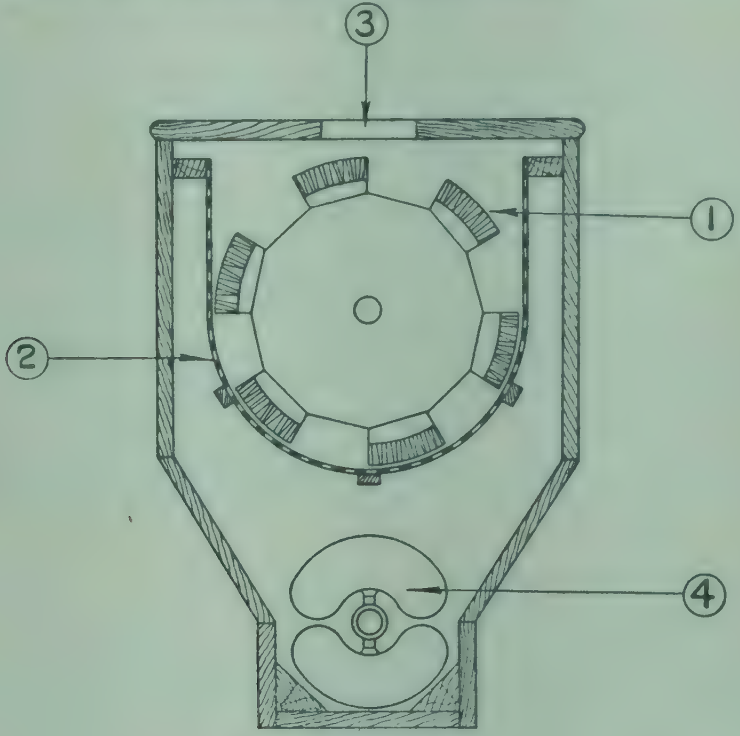


FIG. 55.—Brush sifter.

1. Brush segments. 2. Wire screen. 3. Feed inlet.
4. Worm conveyor.

(4) THE EXTRACTION OF TRAMP IRON

The extraction of tramp iron is dealt with in this chapter because tramp iron should be separated as soon as possible from the raw materials before they pass through the main process machines. Some of the larger fragments of tramp iron are extracted by the cleaning machines already described, but smaller objects pass through the coarse mesh of these machines and are only efficiently extracted by magnetic separators.

In addition, there is always the danger of nuts, bolts and other parts becoming loose in elevators, worm conveyors and other plant. Therefore, all high speed machines throughout the mill, such as grinders and cubing machines, should be protected by efficient magnetic separators. The importance of magnetic separators cannot be over estimated because, apart from the extensive damage likely to be caused to the machines themselves, the attrition of the metal may cause sparks and start a fire.

Magnetic separators are of two main classes:

(1) Those in which the plates are permanently magnetised.
(2) Those in which the plates are kept magnetised by an electric current.

The former are more compact, easier to install, and cheaper, but are not usually so effective except on the shallowest depth of flow; they have to be re-magnetised periodically, and are not self-cleaning. The latter are the more efficient, particularly for depths greater than 1 in., but are subject to

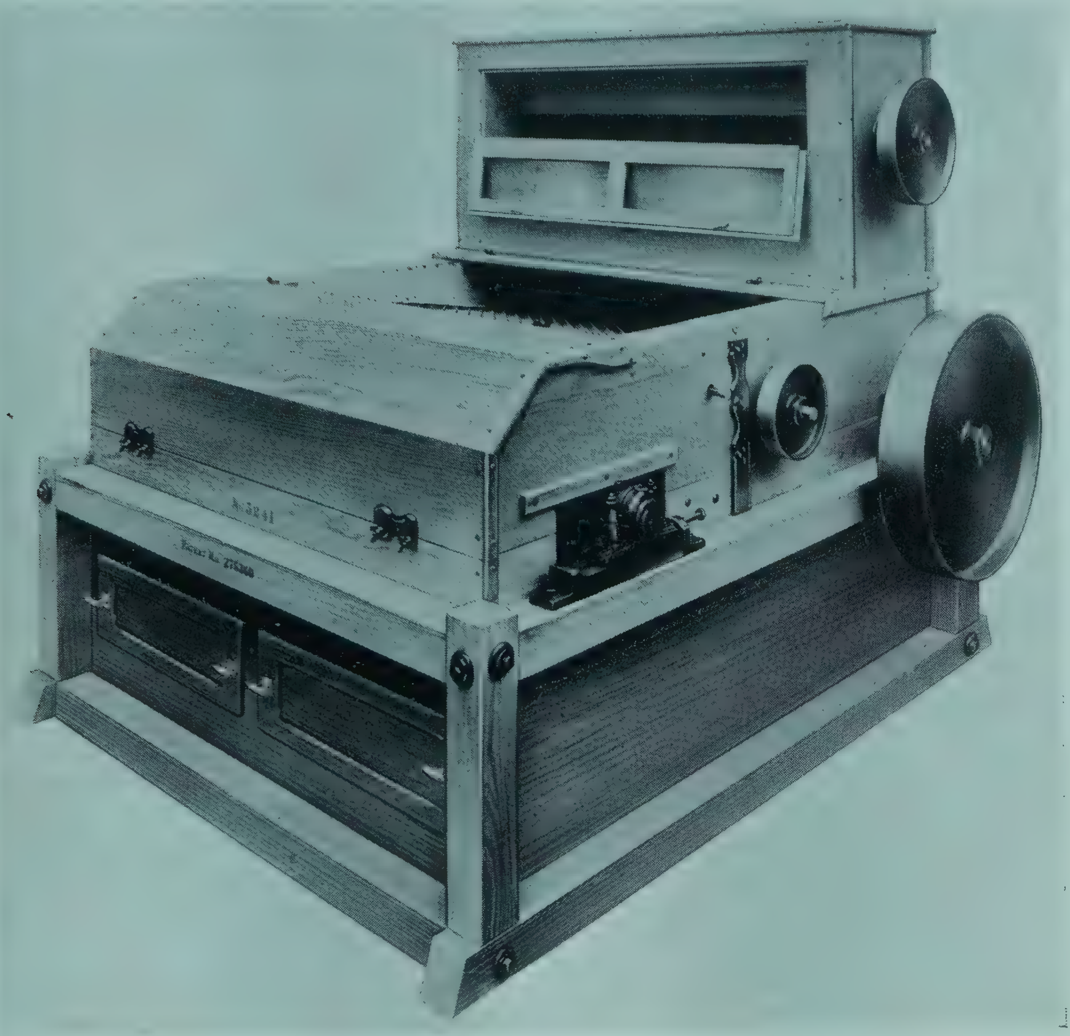


FIG. 56.—Apex rubble separator for meals.

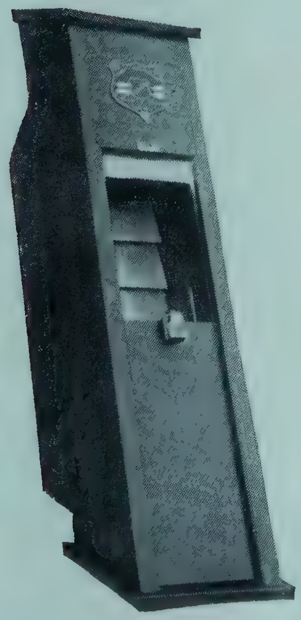


FIG. 57.—Electromagnetic separator.

the failure of the electric current, which must be guarded against by suitable cut out devices and warning signals or lights.

These two classes may be divided into:

(1) *The non-self-cleaning type:*

- (*a*) Horse-shoe magnets.
- (*b*) Permanent magnetic plates.

(2) *The self-cleaning type:*

- (*a*) Electro-magnetic separators.
- (*b*) Drum magnetic separators.
- (*c*) Band conveyor magnetic separators.

HORSE-SHOE MAGNETS

These consist of a number of permanently magnetised plates of horse-shoe shape fixed in two's and three's in spout lids projecting downwards into the meal or grain; they are commonly fitted to grinder feed boxes.

PERMANENT MAGNETIC PLATES

A number of special horse-shoe magnets are arranged in such a way as to form plates. These plates are fitted to the bottom of the spout and retain the tramp iron as the grain or meal flows over.

ELECTRO-MAGNETIC SEPARATORS

These magnets have a number of magnetised plates arranged in a series of steps. A bumping action is imparted to the grain or meal as it flows over the steps, thereby assisting any metal present to settle to the bottom of the stream so that it is more firmly retained by the plate. The material pushes the trapped metal over the edges of the steps into a position which does not obstruct its flow, thus making the magnet self-cleaning.

The plates are magnetised by an electric current passing through coils fixed to the underside of the magnet. If the current fails or is switched off, a trap door normally kept closed by the magnetic pull, drops open and prevents the flow of any untreated material. At the same time the flap releases the iron and steel impurities into a box. Electro-magnetic separators are made by Electro-Magnets Ltd., and W. S. Barron & Son Ltd. (Fig. 57).

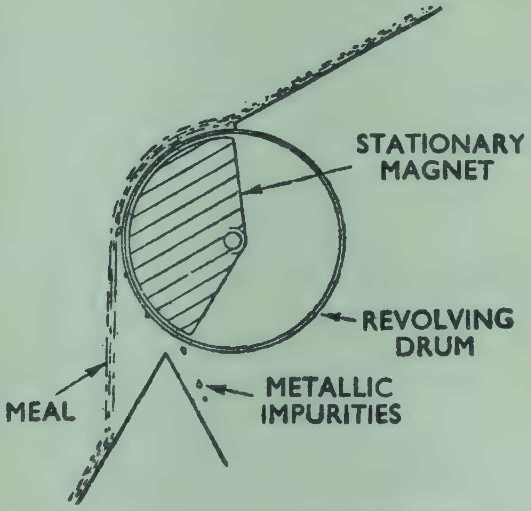


FIG. 58.—Drum magnetic separator.

DRUM MAGNETIC SEPARATORS

This type (Fig. 58) consists of a revolving brass drum containing a stationary magnet. The grain or meal is fed on to the drum and is carried round until it falls into the hopper 1. The metal is held on the revolving drum until it is carried out of the influence of the stationary magnet, which is less than half the circumference of the drum; it then drops into the hopper 2. The stationary magnet may be adjusted through a small arc to suit various materials and working conditions. This self-cleaning magnet is used in compound mills for sticky and non-free flowing materials; it is particularly suitable for molassed meals, for which it is mainly used. Machines are made by Messrs. H. G. Richardson Ltd. and Electro-Magnets Ltd.

Band Conveyor Magnetic Separators

This magnet is not as common as the foregoing but it is sometimes used to remove tramp iron from materials being carried on a band conveyor. The magnet is fitted at right angles over the conveyor and an endless belt running on pulleys travels between the magnet and the material to be cleaned. The metal is held on the belt until it is clear of the magnet and the band conveyor.

Chapter VII

SEED CLEANING

THIS subject, although quite separate from compound milling, is of interest to all millers and corn merchants, particularly at the present time, owing to the need for increased production of home grown crops; it is felt, therefore, that this book would not be complete without a chapter outlining the machines and processes used in the cleaning of grain for seed purposes.

The operations involved in seed cleaning may be grouped under eight main headings :

(1) Aspiration.
(2) Oat clipping.
(3) Separation by size.
(4) Separation by length.
(5) Separation by width.
(6) Separation by surface irregularities.
(7) Separation by colour.
(8) Treatment against fungoid diseases.

(1) ASPIRATION

Aspiration is the separation by air currents of light impurities such as chaff, dust and dirt and should be the first consideration in all seed cleaning plants. Some aspirators, such as the Duo Aspirator, made by Henry Simon Ltd., and the Cyclo Pneumatic Separator, made by Thomas Robinson & Son Ltd., are often used as separate pre-cleaners but, in plants where there are sufficient facilities for aspiration on other machines, they are regarded by many as a luxury. Often the first machine in the plant is the seed cleaning separator which subjects the grain to its initial aspiration in addition to its main function of separating by size.

(2) OAT CLIPPING

There are a number of opinions regarding oat clipping for seed purposes and, if performed at all, it may be carried out at various convenient stages of the plant. Many seed merchants clean the grain with separators before clipping because, by clipping first, the weed seeds and other impurities are broken up and, in many cases, become more difficult to remove.

Some seed merchants are opposed to clipping altogether because, if too drastic, it can damage the germination of the grain. On the other hand, the clipping blades, which remove the hairy tails from the germ end of the oat, are adjustable and can be set for light clipping, which is highly recommended for seed oats. Clipping also improves the bushel weight.

The oat clipper consists of a set of adjustable steel beaters revolving at high speed inside a woven wire or perforated sheet-iron cage. The machine is aspirated to remove the clipped ends and dust. To prevent damage and the danger of fire, a magnet and a small sieve, which is usually part of the machine, should be fitted to trap metal and other foreign matter entering the cage. Perforated sheet iron covers wear better than woven wire covers, but the latter are generally considered to make a better clipped oat. Most oat clippers, such as the Boby and Porteous machines as described on page 221, have interchangeable brushes and beaters, the former being used for polishing the grain.

(3) SEPARATION BY SIZE

Seed Cleaning Separators

Separation by size is carried out by special seed cleaning separators or other machines fitted with reciprocating or rotary sieves. The screens are interchangeable and the separation is determined by the size of perforation according to the size of the particular seed being treated. In the cleaning of wheat, the perforations in the top sieve of the separator are chosen to enable seeds and impurities larger than the wheat to overtail. The wheat then passes through to the bottom sieve, where the perforations are selected to pass through all seeds smaller than the wheat, the wheat overtailing.

Obviously, great care is required in making the right choice from the wide range of screens having either round or elongated perforations. Varieties of grain, even of the same kind and district, may have different characteristics and may contain different kinds of impurities. It is, therefore, advisable first to carry out perforation tests on a laboratory sifter.

Seed cleaning separators are the main machines in the plant, especially as they also have an efficient aspirating system; they are made by all the well-known seed cleaning engineers and embody the same general principles. These include the OZM Seed Cleaning machine made by Thomas Robinson & Son Ltd., the Eureka Seed Cleaning machine, made by E. R. & F. Turner Ltd., the Boby Cleaner, made by Robert Boby Ltd., the Cleaning Separator made by George Porteus & Sons and the Millerator made by Henry Simon Ltd.

The Millerator

The Millerator (Fig. 59) has two slightly inclined sieves in one frame which is given a rotary motion at the head end and a reciprocating motion at the tail. The grain is fed through a spout (*a*) and is spread evenly over the top sieve by the gyrating movement which tails over particles of rubble and seeds larger than the grain being cleaned. A patented retarding device (*b*), consisting of brushes revolving on a sprocket chain, is fitted to the top sieve to prevent good grain tailing over with the rubble and large seeds. The brushes move in the same direction as the tailings but at a slower rate, so that the tailings are subjected to a longer sieving action thus ensuring that good grain has sufficient time to work through the sieve.

The grain falls through the top sieve on to the bottom sieve and is tailed over, the dust and small seeds passing through to the point (*c*). The sieves are kept clean by a ball cleaning device, the balls bouncing between the bottom of the sieve and the wire mesh cover dislodging any obstructions in the meshes.

The grain tailing over the bottom sieve is spread out by a balanced tail gate (*d*) and is subjected to a strong aspiration to remove chaff and light grains. The chaff is carried up the trunk (*g*) into an expansion chamber, where deflectors guide the liftings downwards to a cross worm, which carries them to an outlet. The strength of the aspiration is regulated by valves, the air sometimes being provided by a pair of built-in fans, but generally it is more economical to connect the machine to a central exhaust system.

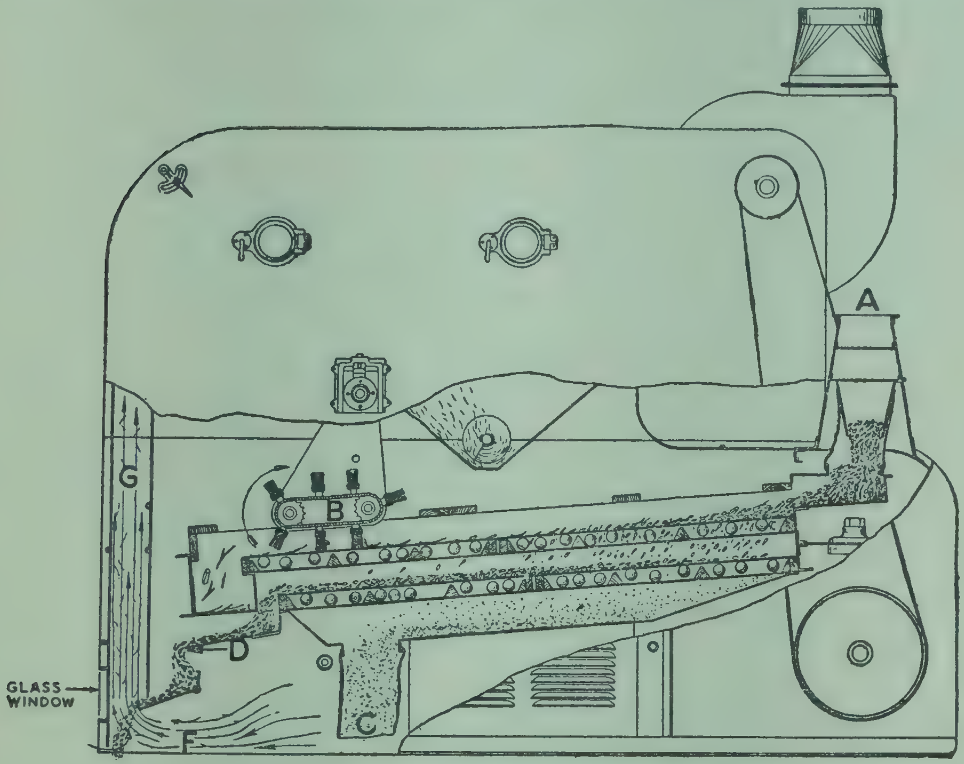


FIG. 59.—Millerator.

(A) Feed spout.
(B) Retarding device.
(C) Dust and small seeds discharge.
(D) Balanced tail gate for grain discharge.
(F) Aspiration.
(G) Trunk for aspirated chaff feeding expansion chamber.

The Boby Cleaner

The Boby all purpose ' Cleenestol ' and ' Supercleen ' cleaners can be fitted with an overhead blower (Figs. 60A & B) in place of the standard feed hopper and as distinct from an aspirator. This is a feature of these machines and the only type of cleaner in which impurities are removed by blowing instead of by suction or aspiration. The makers claim that the continual blast of air, which blows through the seed before it reaches the first screen, is particularly suitable for dealing with damp and/or dirty crops direct from combine harvesters and that, in many of these conditions, blowing has advantages over aspirating.

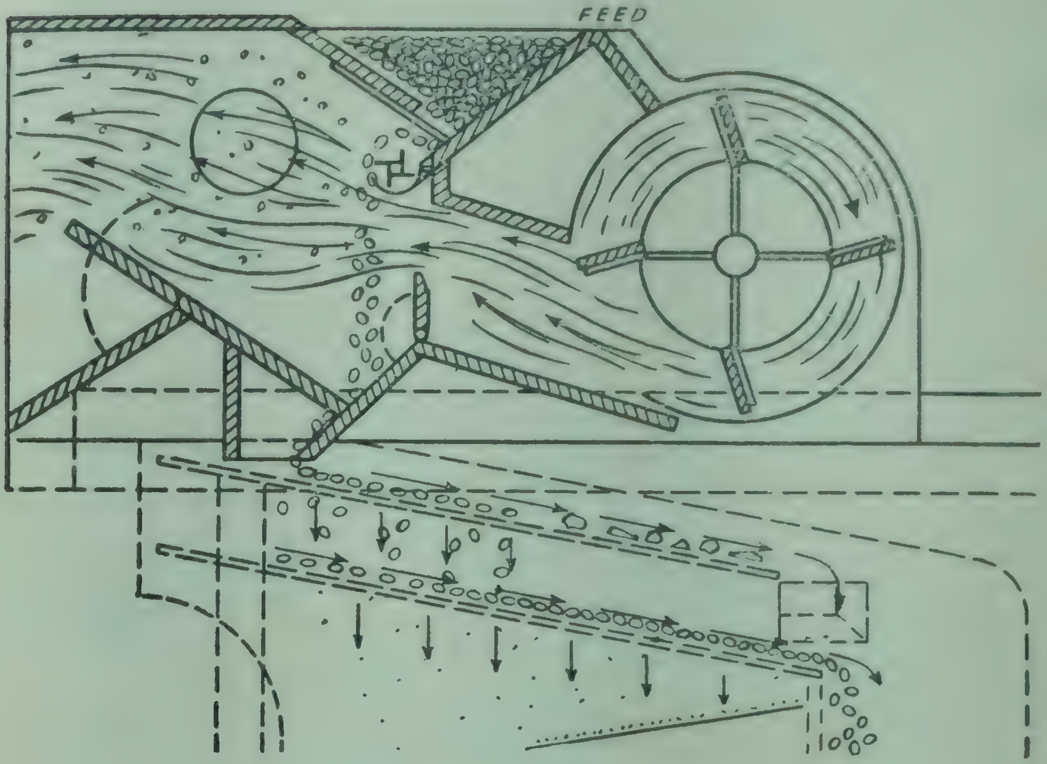


FIG. 60A.—Boby cleaner.

(4) SEPARATION BY LENGTH

This is the next operation in order of sequence and it is performed either by disc separators or indented cylinders. The function of these machines is to pick up the grain or seed impurities in the indents and deposit them either in troughs between the discs or in the tray inside the cylinder. It should be noted that the term ' length ' not only applies to the length of a long thin grain, such as an oat, but also to the diameter of large round seeds.

The Disc Separator

The Disc Separator made by Henry Simon Ltd. (Figs. 61 A and B), has a number of cast-iron discs mounted on a horizontal shaft which revolves at 40-60 r.p.m. in the mass of grain. The discs are indented on each side by numerous small pockets, which are the same shape as the grain or seed to be separated. The pockets may lift the grain from larger foreign seeds or they may pick out foreign seeds smaller than the grain itself; for example, when cleaning wheat, one disc separator lifts the wheat and rejects the longer oats and barley, and a second separator picks out the smaller cockle and vetch, leaving the wheat.

The liftings of the pockets are discharged into troughs between the discs on the downward side; a row of hinged flaps enables these liftings from any part of the machine to be either spouted away through the hopper or returned by a small worm conveyor to the head of the machine for re-treatment. The grain left behind is conveyed along the machine to an opening at the tail end by means of inclined blades fitted to the centres of the discs.

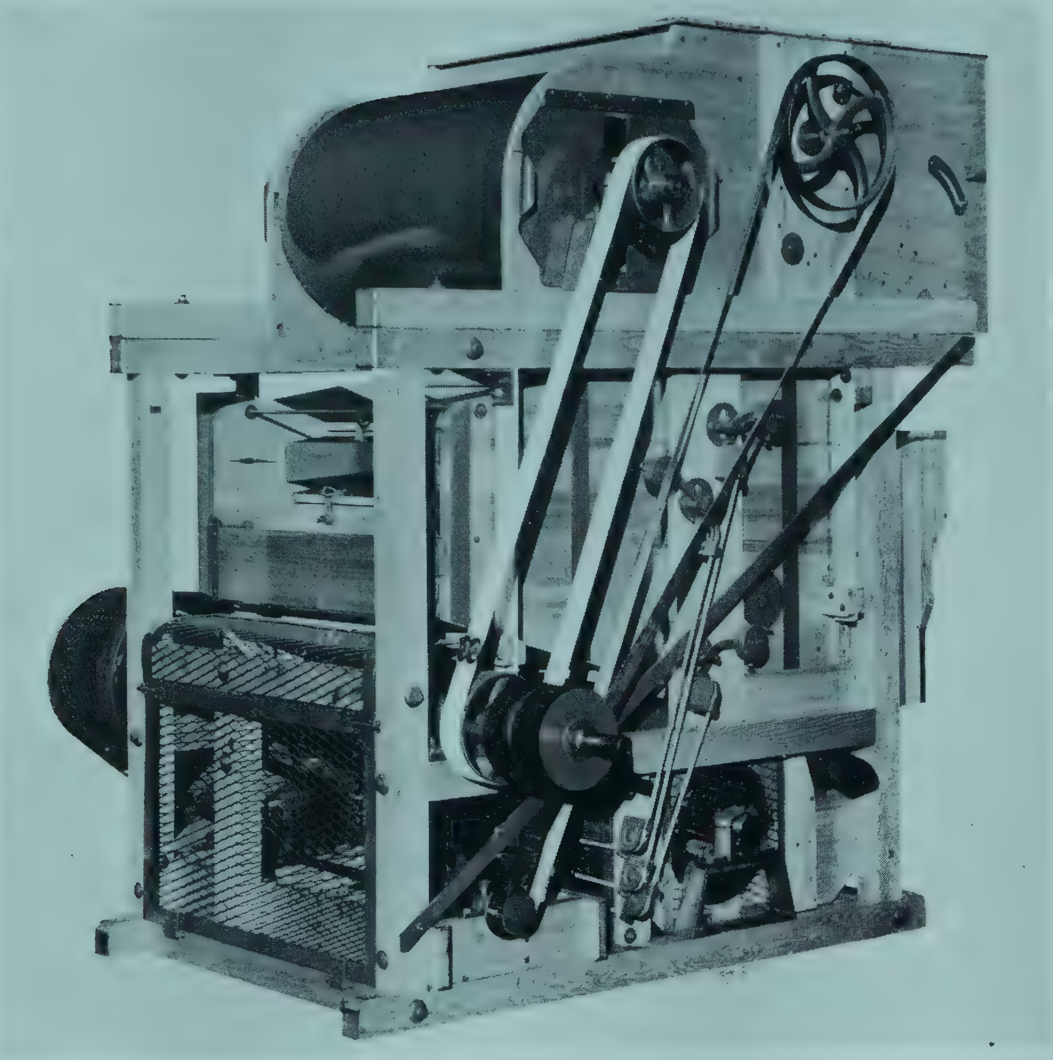


FIG. 60B.—Boby cleaner.

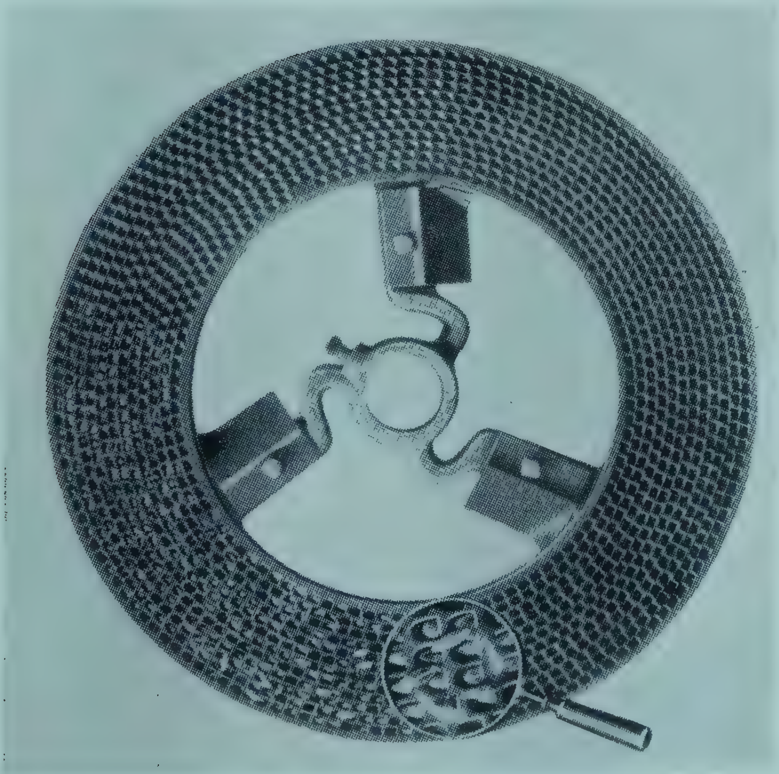


FIG. 61A.—Section of disc separator showing indents

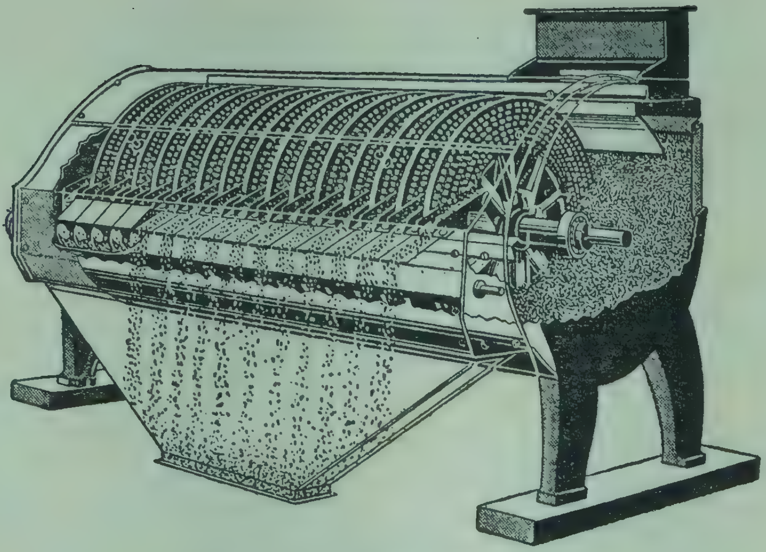


FIG. 61B.—Disc separator.

Indented Cylinders

Indented cylinders are intended for the same type of work as the disc separator and are made by a number of manufacturers, notably by Thomas Robinson & Son Ltd. and Robert Boby Ltd. Cylinders consist of circular covers of pressed steel or drilled zinc indents. Both are commonly used, but zinc does not wear as well as steel. As the cylinder revolves, either the grain being cleaned or the impurity, depending on the size of the indents, is picked up and dropped into a tray containing a worm conveyor (Fig. 61 B). The quantity of liftings is adjusted by lowering or raising the tray on the rising side of the cylinder.

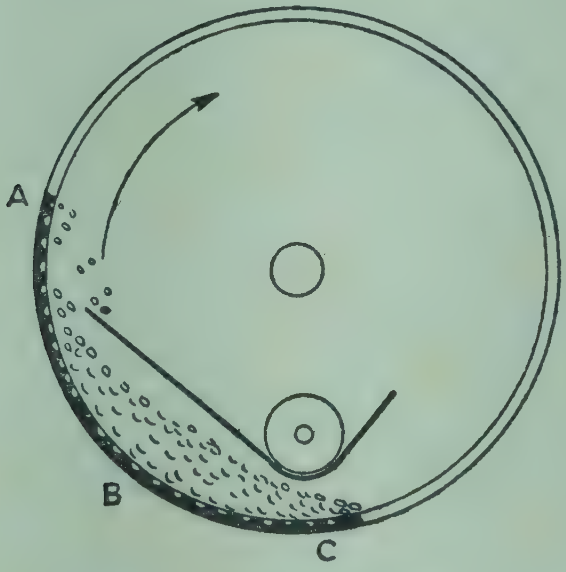


FIG. 62.—Action of cylinder.

The Robinson ultra-indented cylinder (Fig. 63), has a special spreading device, suggestive of a lawn mower cutter, which revolves in the opposite direction to the cylinder. This has the effect of throwing up the grain on the down-coming side of the cylinder thereby breaking up and spreading the mass. By this means, the area of contact between the cylinder and the grain is increased with a consequent increase in capacity. Cylinders may be adjusted by opening or closing their outlets, which alters the rate of flow and lowers or raises the height of the grain inside the cylinder.

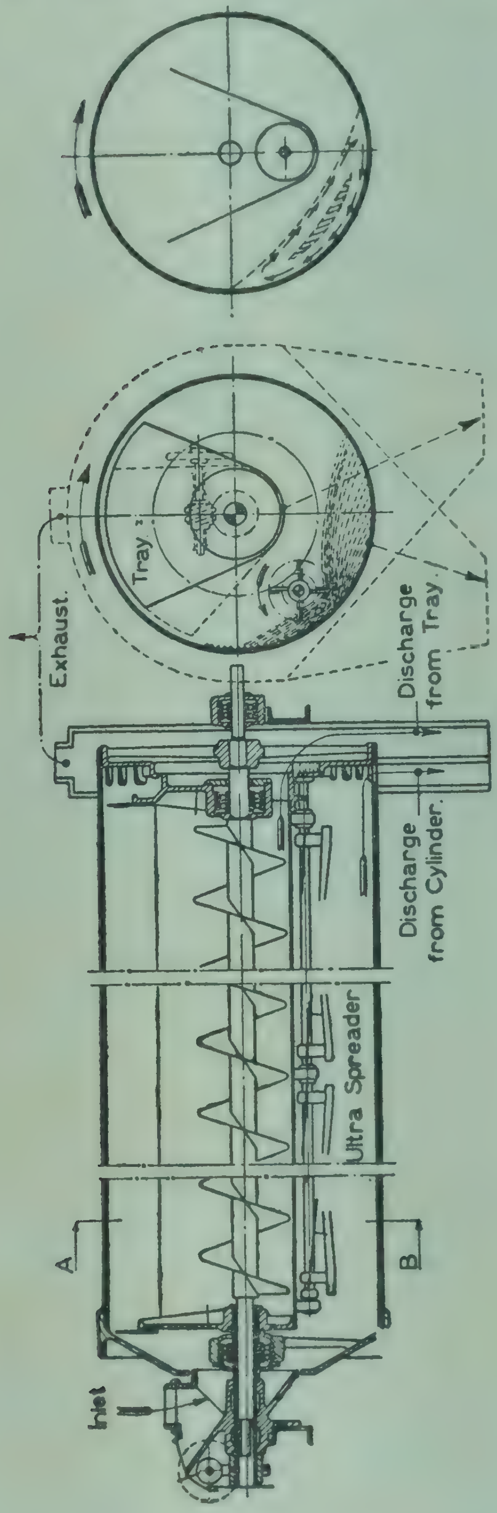


FIG. 63.—Robinson ultra-indented cylinder.

A feature of the Boby cylinder (Fig. 64) is its interchangeable cover which enables new covers to be fitted when worn; it has a rotary tray regulator for easy cleaning purposes.

When cleaning wheat, it is usual to install two cylinders, one above the other. The top cylinder separates the small seeds and impurities shorter than the wheat, and the bottom, larger impurities, such as barley and oats. Cylinders and disc separators are used for removing long impurities from grass and clover seeds, lucerne, trefoil, linseed and other small seeds and also for removing broken seeds from larger seeds such as barley, oats and rice.

Thomas Robinson & Son Ltd., manufacture an all-purpose machine embodying three cylinders in one frame, one above the other, which can be used for grass as well as various types of grain. They also manufacture a machine combining two cylinders in parallel which are preceded by a grading reel. The reel has a wire grid, which is cleaned by a rotating brush, for selective grading so that subsequent treatment in the cylinders is more searching.

All Robinson ultra-indented cylinders are fitted with a variable speed drive so that speeds may be varied from 5 to 50 r.p.m. to suit the particular seed being cleaned.

The Spiral Seed Separator

This machine is described at this point because it is used for separating large round seeds from the liftings of disc separators or cylinders when cleaning certain types of wheat and other grain. The machine (Fig. 65) is

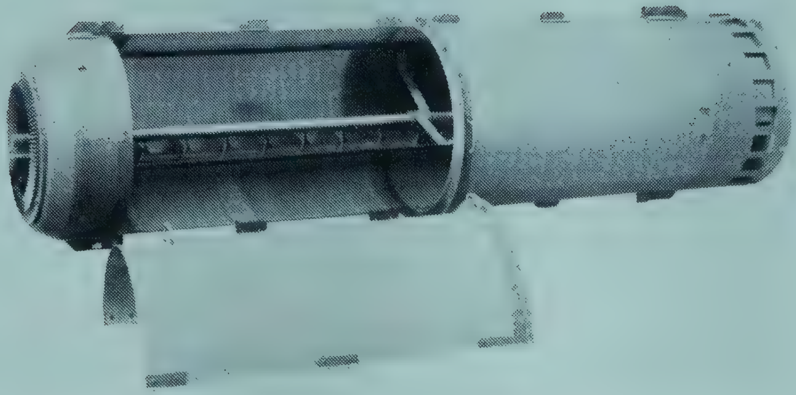


FIG. 64.—Boby cylinder.

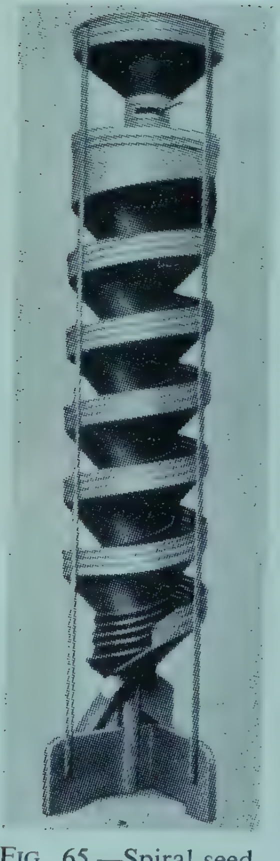


FIG. 65.—Spiral seed-separator.

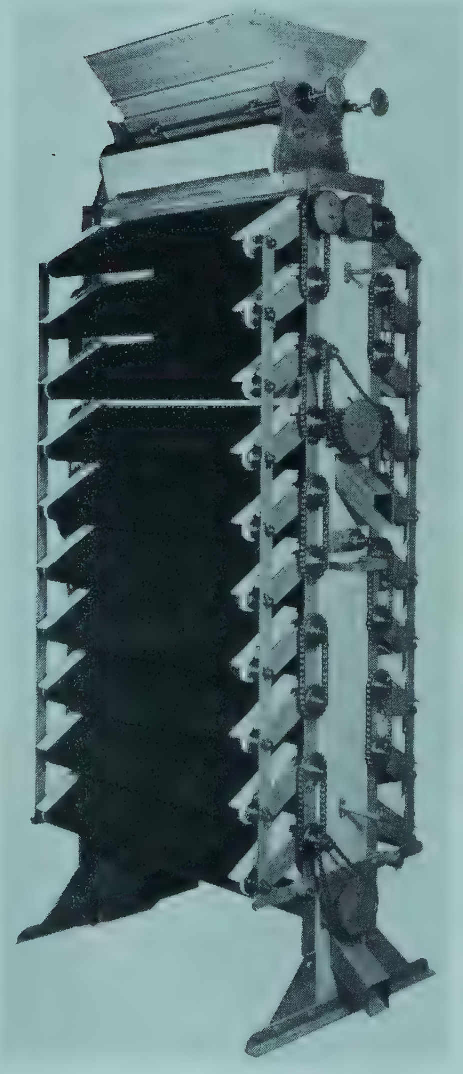


FIG. 67.—Dossor seed-dresser.

like a miniature ‘ helter-skelter ’ and simply comprises a number of sheet metal spirals. A special feeding vane is rotated by the incoming grain and spreads the seeds over the spirals. Round seeds that roll easily attain a high speed and consequently tend to fly off into the outer spiral while the wheat and similar flat sided grains remain near the inner spiral. The seeds are then diverted to their respective destinations by cut-off valves at the foot of the spirals. This machine makes a good separation and requires no motive power, but it has a limited capacity depending on the quantity of round seeds in the grain.

(5) SEPARATION BY WIDTH

The Nalder Grader

The Nalder Grader (Fig. 66) is a machine for making separations by width; it is specially designed for separating seeds which, apart from slight variations in width, are of approximately equal dimensions, which are difficult to separate by seed cleaning separators, disc separators or cylinders. The separation has to be particularly accurate and the machine is generally used for sizing plump and thin grains of seed oats and barley; it follows the disc separators or cylinders.

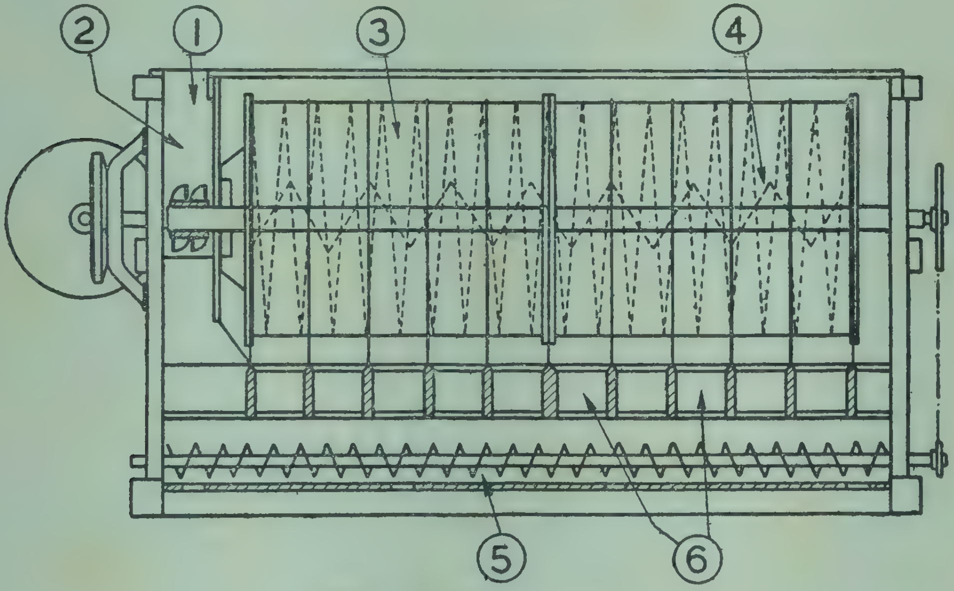


FIG. 66.—Nalder grader.

1. Feed inlet. 2. Inclined blades. 3. Grading cylinder. 4. Worm conveyor. 5. Collecting worms. 6. Throw-over valves.

In Fig. 66 it will be seen that the grain is fed through the spout (1) and, by means of the inclined blades (2), is carried into the grading cylinder (3). The cylinder is constructed of a number of rings to which longitudinal bars are fitted, a single strand of tempered steel wire being wound spirally round this framework. Notches are cut in the bars so that the wire may be spaced with great accuracy and adjusted to any particular requirements.

The mass of grain is carried along the revolving cylinder by the worm conveyor (4). The thin grains pass through the wire and fall into the hopper which contains two collecting worms (5) arranged side by side in separate boxes. Thicker or wider grains may be separated progressively by each succeeding section towards the tail end of the cylinder by slightly widening the pitch of the wire in the proportion desired. A throw-over valve (6) is fitted under each section so that the troughs from any section may be sent to either worm. The worms are of the paddle blade type which enables the blades to be reversed in order to convey the grain in either direction from any part of the cylinder to a series of outlets along the worms.

(6) SEPARATION BY SURFACE IRREGULARITIES

Some machines take into account the surface irregularities of seeds, as distinct from their difference in size with which the majority of seed cleaning machines are concerned. The principal machines of this type are the ‘ Dossor ’ seed dresser, made by Robert Boby Ltd., and the ‘ Purex ’ magnetic separator, made by the Rapid Magnetic Separator Co. Both machines are suitable for separating weed seeds, which have rough coated or broken surfaces, from the small, smooth-coated clover or other similar seeds. The ‘ Dossor ’ machine separates weed seeds with projecting surfaces and the ‘ Purex ’ weed seeds with indented or pitted surfaces.

The ‘ Dossor ’ Seed Dresser

The ‘ Dossor ’ Seed Dresser (Fig. 67), comprises a feed hopper and a frame containing twelve inclined, superimposed cleaning sections, each having a running belt with a special velvet surface. The clover seeds, owing to their smooth and slippery coats, roll off the inclined belts from section to section, while broken seeds, crowfoot, rib grass, and other seed impurities with rough projections are caught in the nap of the velvet and tailed away. A feature of this machine is its large cleaning area provided by the constantly changing surfaces of the numerous running belts.

Another ‘ Dossor ’ machine, known as the D2, contains twenty velvet sections, ten on each side with a split feed ; this saves space and doubles the capacity.

The ‘ Purex ’ Magnetic Separator

The ‘ Purex ’ Magnetic Separator is similar in principle to the revolving drum magnetic separator described in Chapter IV. In this case, however, VI the seed to be cleaned is first treated with a mixture of fine iron powder and water, which only adheres to those seeds having broken and indented surfaces. The indented surface seeds with the iron powder coats are held by the magnet for two-thirds of the drum’s revolution but the smooth-coated seeds are not affected, and pass directly over the drum.

The Special Cylinder for Cleaning Peas

This is another machine which separates by surface irregularities; it is used for cleaning peas of which a large proportion contain holes. These holed peas, being of the same weight and size as the good peas, are not removed by ordinary separators. The cylinder is somewhat similar to the indented cylinder, but contains a large number of steel needles instead of indents. The needles catch in the holes and deposit the holed peas in the cylinder tray, leaving the good peas behind.

(7) SEPARATION BY COLOUR

Seeds that are similar in all the foregoing respects may be separated by electronic means through their difference in colour. These machines are at present mainly used in the trade for sorting beans and peas for canning, and their output is very low compared with other cleaning machines, they save considerable labour for this purpose because the only other method of sorting is by hand. It is hoped to use the principle for the elimination of damaged and off-colour grains from smaller seeds, such as wheat, barley and rice, which may open up a number of possibilities, but at present the cost of these machines is too high for low priced products.

The machine made by R. W. Gunson (Seeds) Ltd. will sort up to 185 pounds per hour of beans and peas. Briefly, the principle, as illustrated in Fig. 68, is somewhat similar to that employed in the drum magnet or the 'Purex' Magnetic Separator except that an electrical field is used instead of a magnetic one. The seeds, which pass through the machine in single file over a band feeder, are viewed from all angles by two photo cells. The unwanted discoloured seed then receives an electric charge and, through electronic action, falls into a different path to the good seed.

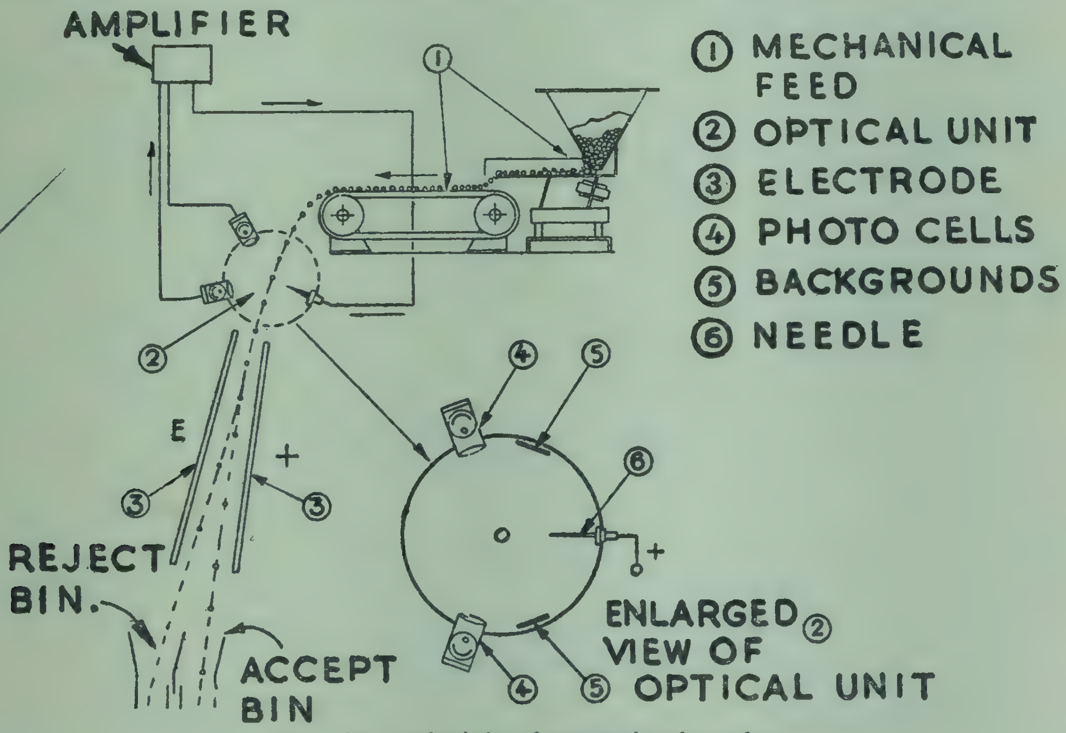


FIG. 68.—Principle of separation by colour.

(8) TREATMENT AGAINST FUNGOID DISEASES

POWDER DRESSING MACHINES

The powder dressing machine is a necessary addition to all efficient seed cleaning plants. The object of the machine is to mix a regulated quantity of mercurial powder with the grain as a preventive against certain fungoid diseases. The spores of the fungus are carried on the grain and, if not killed, perpetuate the disease from season to season.

Fig. 69 shows the machine manufactured by E. R. and F. Turner Ltd. It consists of a powder feeder, a seed feeding box, a mixing drum, and twin sacking-off spouts, each controlled by a slide so that the operation is continuous. The powder feeder is situated on the top of the seed-feeding box and consists of an open-link chain carried on sprockets and enclosed in a hopper. The chain runs through the hopper at the bottom of the feeder so that a quantity of powder is carried forward by the links. A spring then releases the powder into the seed feeding box. The quantity of powder to be mixed is governed by the speed of the chain, which is regulated by a ratchet feeder. The seed-feeding device incorporates a fluted roll and adjustable feed plate contained in a metal feed box with a wooden top and glass door. The lower part of the box contains the totally enclosed bevel gears for driving the mixing drum. The mixing is done by an inclined steel worm encased in a detachable sheet metal cover which rotates with the worm. This action results in the seed receiving a very thorough coating of the powder with a minimum of attention.

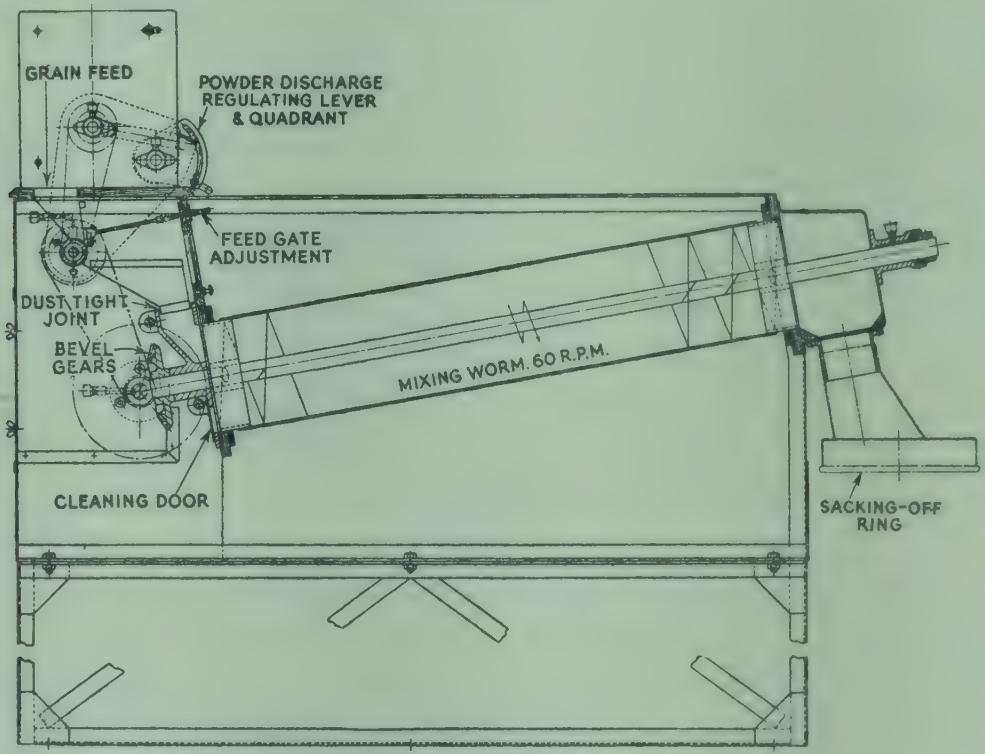


FIG. 69.—Turner powder-dressing machine.

Another type of Turner machine is fitted with a revolving reel instead of a worm; it gives a higher capacity and is particularly suitable for lighter seeds, such as sugar beet and mangold.

The Robinson machine (Fig. 70) embodies a patent chemical powder feeder, an automatic cut-out, which stops the machine if the regulated grain capacity drops, and a special mixing chamber, the lower half of which is hinged to allow the discharge end to drop for cleaning purposes.

Powder-dressing machines should have an exhaust system at the sacking-off point to prevent the powder dust, which can be harmful to operators, escaping to the atmosphere. The Turner machine may be fitted with the

'Katchall' dust collecting unit. This unit employs a small fan to suck the dust-laden air from round the sack and blow it into a special fabric dust filter, which discharges the clean air and collects the dust by passing it over an oil-filled trough. Similarly, the Robinson machine may be fitted with a small fan which blows the dust-laden air through a short pipe into a filter sleeve.

A Typical All Purpose Seed Cleaning Plant for the General Miller or Seed Merchant

Fig. 71 shows a typical Simon all-purpose seed cleaning plant suitable for cleaning wheat, barley, oats, beans or peas. Before reaching this plant the grain may be subjected to a rough preliminary cleaning as described in Chapter IV.

Seed Cleaning of Wheat

In Fig. 70 the wheat is fed to the Millerator, which separates large and fine impurities on the top and bottom sieves respectively. An independent fan and a dust collector exhaust the dust, chaff, and other dirt from the Millerator and the other machines in the plant.

The wheat then passes to the first disc separator which removes any oats and barley. The wheat is lifted by the disc pockets, but a small quantity of oats and barley may be lifted with the wheat at the end of the machine. For this reason it is advantageous to fit two wing valves with separate outlets into the discharge hopper, so that this small quantity containing the oats and barley may be sacked-off and prevented from passing to the second disc separator. One of these separations is suitable for milling purposes while the other should be re-treated.

The wheat then passes to the second disc separator which lifts out the cockle and other small seeds. The overtails of this machine is clean seed wheat, which may be sent direct to sack or to the powder dresser.

Seed Cleaning of Oats and Barley

When cleaning either oats or barley, the grain is fed to the Millerator, as in the case of the wheat, but a different set of sieves with covers suitable for removing the different type of seed impurities has to be fitted. The oats and barley then by-pass the first disc separator and go direct to the second disc separator for the extraction of cockle and small seeds.

The overtails of this second disc separator then pass to the Nalder graders, which separate the thin grains from the full-sized seed oats or barley. A number of sections with different sizes of mesh are provided with this machine so that the miller or seed merchant is able to obtain the type of seed that he requires.

Cleaning of Beans and Peas for Seed

The cleaning of beans and peas may be carried out satisfactorily on the Millerator provided that a suitable set of covers are fitted to the machine. Peas containing a large percentage of holed grain may be passed through a special cylinder fitted with needles.

Cleaning Grass and Lucerne Seed

The plant shown in Fig. 71 may also be used for the cleaning of grass seeds but different problems are involved. Grass and lucerne seed is frequently received in a damp condition and requires drying before cleaning.

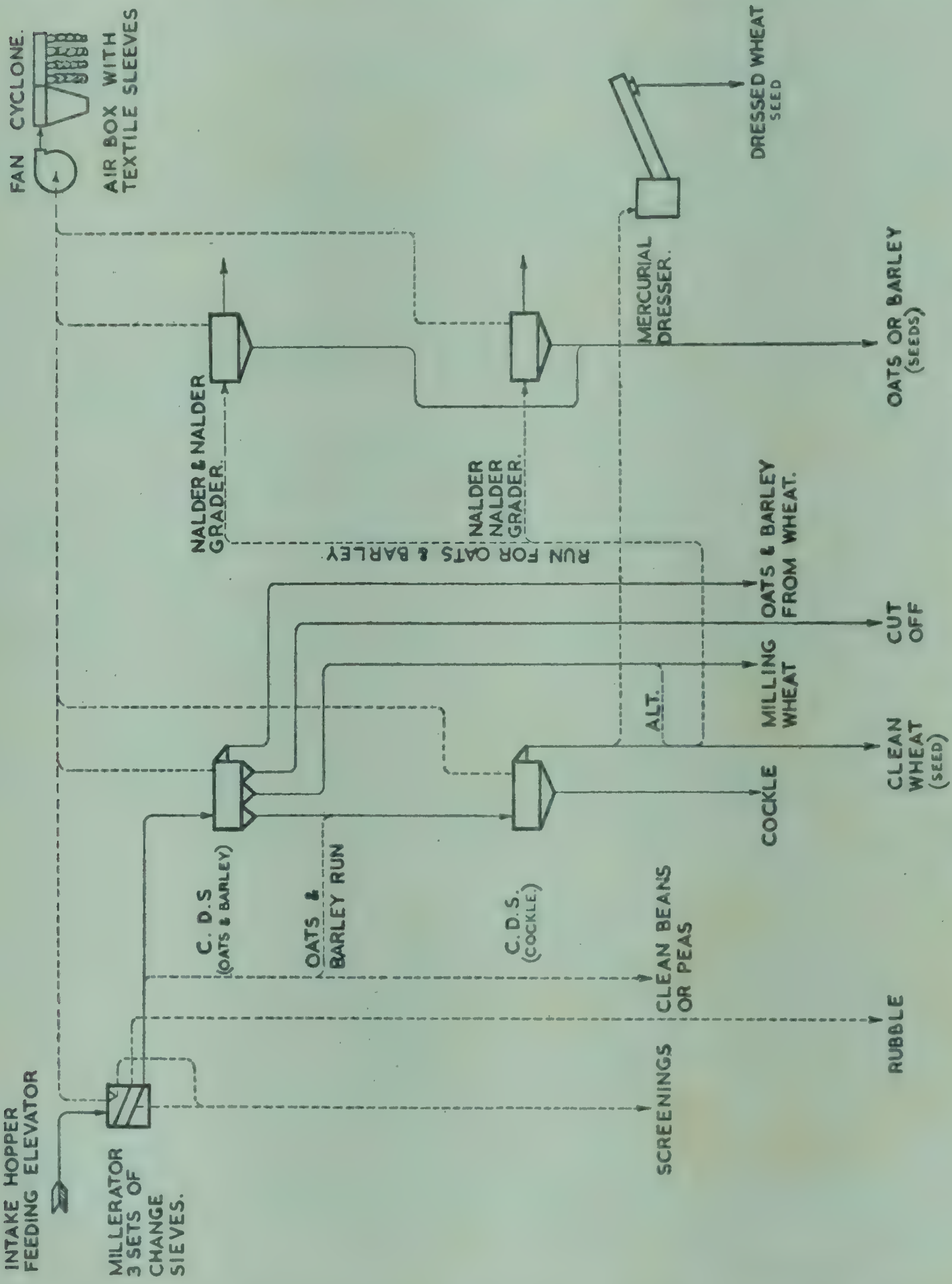

FAN
CYCLONE.
AIR BOX WITH TEXTILE SLEEVES
DRESSED WHEAT SEED
MERCURIAL DRESSER.
NALDER & NALDER GRADER.
NALDER NALDER GRADER.
RUN FOR OATS & BARLEY
OATS OR BARLEY (SEEDS)
OATS & BARLEY FROM WHEAT.
CUT OFF
MILLING WHEAT
ALT.
CLEAN WHEAT (SEED)
COCKLE
C. D.S. (OATS & BARLEY)
OATS & BARLEY RUN
C. D.S. (COCKLE)
CLEAN BEANS OR PEAS
RUBBLE
SCREENINGS
INTAKE HOPPER FEEDING ELEVATOR
MILLERATOR 3 SETS OF CHANGE SIEVES.

Fig. 71.—Seed cleaning plant for wheat, oats, beans and peas.

The seed as received contains a large quantity of broken stalk and leafy matter and will not run freely until this has been taken out. It is therefore necessary to subject the dirty seed to a heavier aspiration than other types of seed. This may be performed by the aspirating section of the seed cleaning separator, and the blowing method, as used in the Boby cleaners,

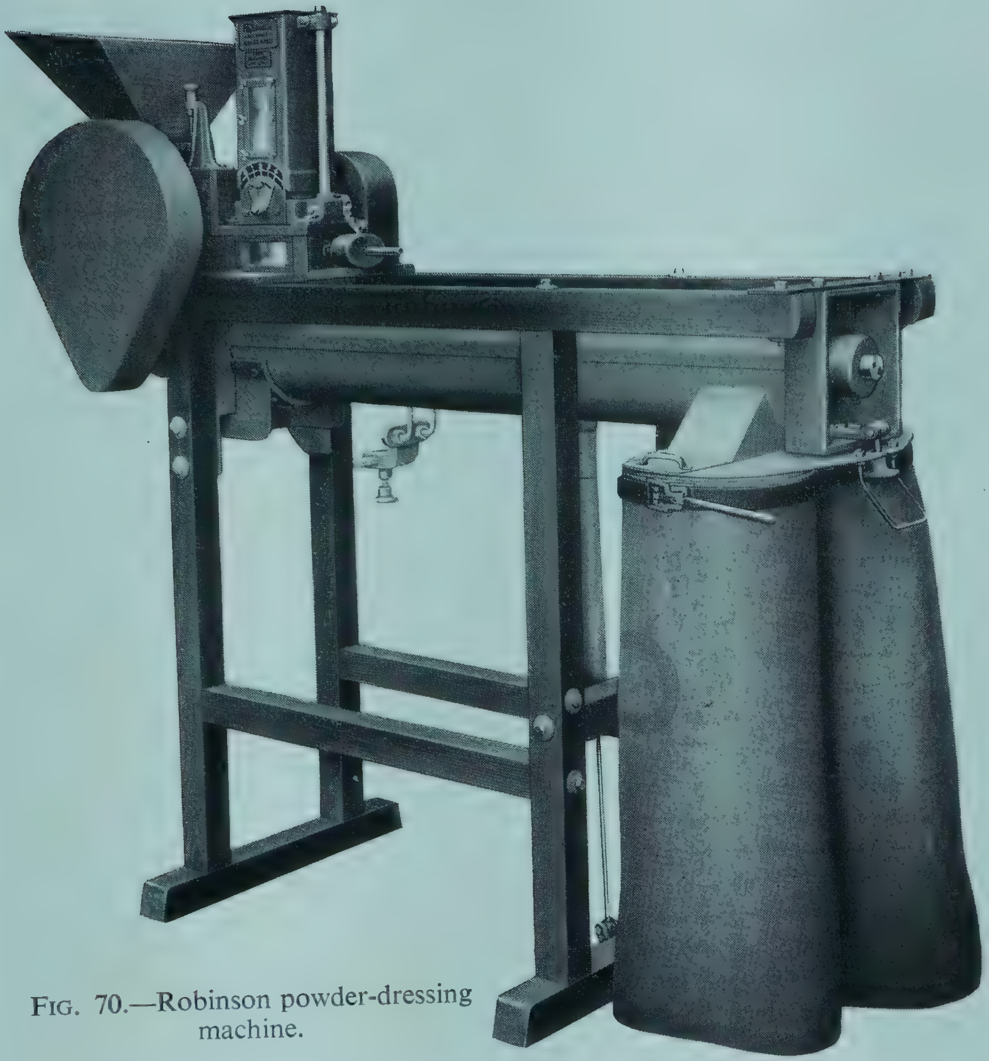


FIG. 70.—Robinson powder-dressing machine.

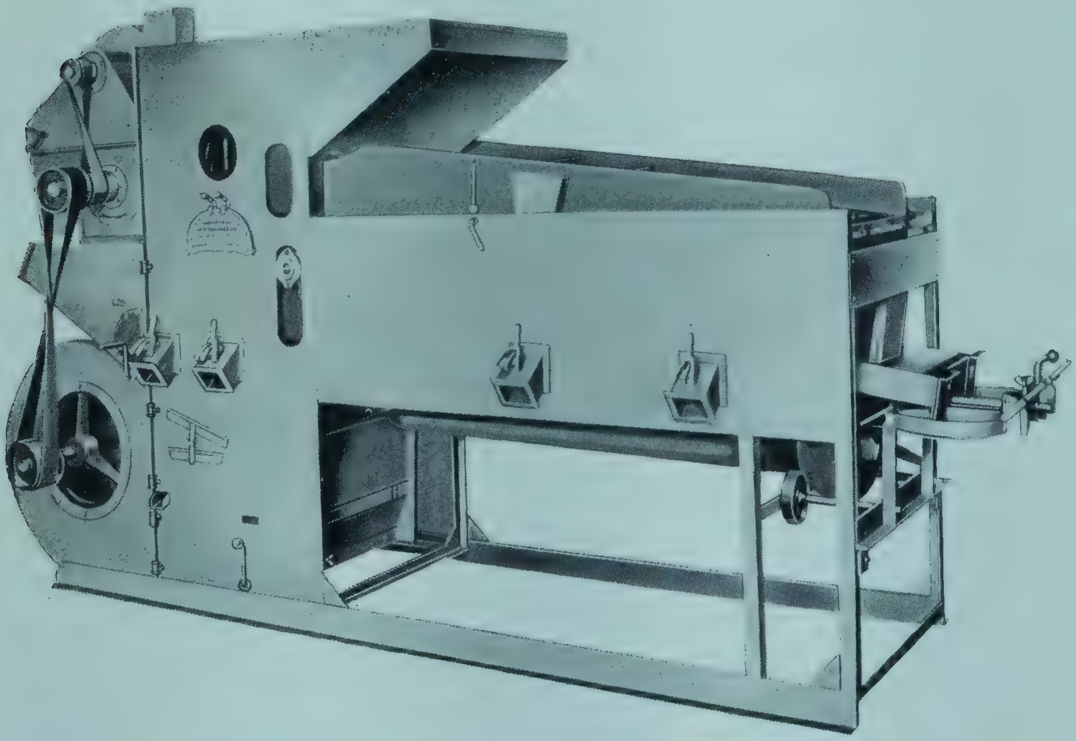


FIG. 74.—Kaybee ' 50 ' self-contained seed-cleaning plant.

is particularly suitable for this purpose. In addition, the intake hopper to the first machine should be fitted with an agitator.

As a vigorous action is required to keep the seed moving, the movement of standard separator sieves should be speeded up and the screens continually tapped and cleaned. The top and bottom sieves remove the large and small impurities respectively as previously described. The seed is then finally cleaned on disc separators or cylinders.

A SEED-CLEANING PLANT USING COMBINED SIFTERS

This type of plant is a recent development by Henry Simon Ltd., in which three types of sifters may be used either as individual units or in combinations of two or three. A large number of different combinations for a wide variety of purposes may be arranged. A typical arrangement of a plant for cleaning 5 tons per hour of wheat is shown in Fig. 72.

Each machine is housed in an identical steel case with feed connections at the top and side, and doors and windows in each end and side. The cases are arranged so that, where machines are used in combination, they may be mounted on top of each other. This design gives economy of space, neatness and vibration-proof rigidity.

The sieve box is mounted inside the aluminium alloy casing and is suspended from cones. The motor drives the sieve through belts to a balanced eccentric mechanism. The sieves having metal frames, are carried in ' drawer type ' sieve traps to provide flexibility and ease of replacement. All the parts are standardised and interchangeable.

Each machine has been designed to impart a different motion to its sieves, and since each motion has its own special effect on the grain, each machine is ideally suited for making a separation of a particular type, based on a particular characteristic of the grain. The motions which are most commonly used in seed cleaning are two in number and each is employed in one of the combined sifters, as follows:

1. RECIPROCATING ACTION—THE SHUTTLESIFTER

A straightforward reciprocating motion along the long axis of the sieve tends to turn the grain until its long axis lies parallel to the axis of the motion. The tendency, as the grain is ' shuffled ' along the sieve, is for it to tip up and to fall through the perforations point first. The separation made in this way is therefore on the basis of width.

This motion is employed in the Shuttlesifter which is designed as a width separator. It is a single sieve machine, equipped with a feed connection at the head of the sieve and with connections for exhaust. It is possible to take off the throughs and the overtails for further treatment on either of the other two types of sifters. The sieve is driven direct from a balanced eccentric attached to the head end of the box, which produces the reciprocating motion: it may be fitted with a patented device for retarding the flow of material. This device—which is similar to that employed on the scalping sieve of the Millerator—consists of a band of the same width as the sieve and carries brushes or flexible strips. The band travels over sprockets above the sieve, with the brushes in contact with the surface, and at a speed below that of the sieve so that the material is held up. Any sound grain carried in the overtails is thus allowed to work its way through the sieve instead of being borne over the tail.

2. ROTARY ACTION—THE ROTOSIFTER (Figs. 73A & B)

A rotary motion causes the grain to lie flat on the surface of the sieve, and thus to present its longest dimension to the perforations. This separation is therefore on the basis of length.

The Rotosifter, which employs this action, is a double-sieve machine in which it is possible to take off the throughs or overtails of each sieve independently. A feature, unique to this machine and the Trigosifter, is the provision of a sloping plate between the sieves, which directs the throughs of the upper sieve to the head of the lower one, instead of allowing them to fall straight on to the lower sieve. This means that the whole surface of the lower sieve is used effectively. The surface at the head of the sieve is not wasted as in many other double sieve machines.

The drive is similar to that of the Shuttlesifter. The sieve box, suspended from canes, is mounted on a balanced eccentric which imparts a rotary motion.

3. MILLERATOR ACTION—THE TRIGOSIFTER

A combination of the two motions employed in the Shuttlesifter and the Rotosifter gives the same action as the Millerator and subjects the grain to both types of separation, by width and by length, successively in the same machine. It is this action which is employed in the Trigosifter and the machine, as far as sifting is concerned, performs the same work as the Millerator. The aspirating work of the Millerator is, in the case of the Trigosifter, performed by a pneumatic aspirator in a pneumatic plant or by a Twin Lift aspirator in a bucket elevator plant.

The Trigosifter is a double sieve machine with similar arrangements for feeding and taking off material to those in the Rotosifter. The Millerator action is imparted to the sieve by a rotary balanced eccentric drive at the head end, which causes the head of the sieves to rotate while the tail end, being mounted on slides, oscillates in an almost straight line parallel to the long axis of the sieve. The sloping plate between the sieves, described for the Rotosifter, is also incorporated in the Trigosifter, while the upper sieve, like the single sieve of the Shuttlesifter, may be fitted with the patented retarding device if this is desired. The Trigosifter has many applications in the Compound mill.

In the flow diagram (Fig. 72), the characteristics peculiar to each machine have been used to provide the effect for which each is best suited. Uncleaned wheat is fed to the Rotosifter, the uppermost of the three machines. Here, the straws, unthreshed wheat heads, etc., which may clog the following sieves, are removed on the top sieve while the wheat and the remaining impurities fall to the bottom sieve. The bottom sieve grades the large and small wheat, the stream of large wheat holding the large impurities, such as maize, and the stream of small wheat containing the small seeds. The large wheat, overtailing the bottom sieve of the Rotosifter is sent to the Shuttlesifter, which removes the maize, etc. It has the most effective sifting motion for this separation and its efficiency will be enhanced since it

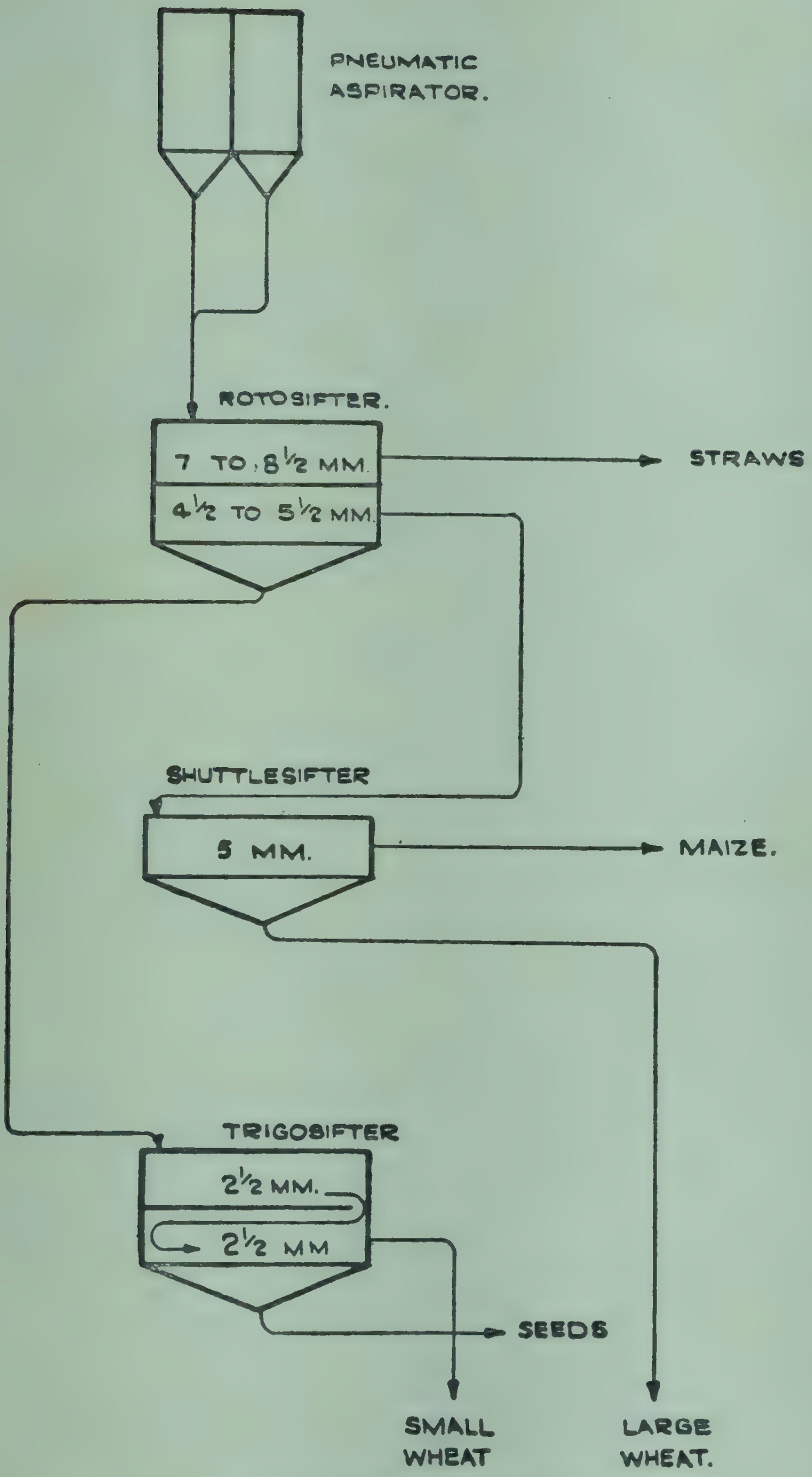

PNEUMATIC ASPIRATOR.
ROTOSIFTER.
7 TO 8½ MM.
4½ TO 5½ MM.
STRAWS
SHUTTLESIFTER
5 MM.
MAIZE.
TRIGOSIFTER
2½ MM.
2½ MM
SEEDS
SMALL WHEAT
LARGE WHEAT.

FIG. 72.—Seed cleaning of wheat as in combined sifters.

will be working on only half the original feed. The stream of small wheat passes from the Rotosifter to the Trigosifter both sieves of which are used to remove small seeds.

The motion of the Trigosifter is ideal for the removal of small seeds from wheat and has the added advantage of making the sieve cleaners work most effectively. Clogging of the sieves is avoided, as has been proved by long experience of the seed sieve of the Millerator, which has become very popular for this separation. The two grades of wheat, large and small, resulting from these separations, will not only have been subjected to a very thorough and efficient cleaning, but will also be in much better shape, by reason of the size grading, for further treatment, for example on disc separators.

Grass Feeder and Separating Sieve

Thomas Robinson & Son Ltd. manufacture a Combined Grass Seed Feeder and Separating Sieve for separating grass seed. The feeder consists of a band having rows of studs which, in conjunction with an adjustable feed hopper and an agitator rake, ensures an even flow of this type of seed.

The sieves are kept clean by automatic tappers and are interchangeable. The suspension is adjustable, which enables the throw to be modified for different types of seed.

If desired, both combinations of the machine can be connected to an exhaust system.

Self-Contained Seed-Cleaning Plants

The Kaybee ' 50 ' self-contained plant (Fig. 74) supplied by T. R. Walker may be used for a number of purposes, and occupies only a small space. It incorporates five machines in one frame including a clipper, a combined cleaning unit and a cylinder. The cleaning unit consists of a feed hopper, fluted feed roll and graduated control slide, a scalper screen fitted with brush cleaners and a fan with twin aspiration. The grain is elevated pneumatically, stones and tramp iron being removed by air sorting. The pressed steel cylinder covers are interchangeable to suit various types of seed.

ACCESSIBILITY OF MACHINES AND PLANT FOR CLEANING PURPOSES

An important factor in a seed-cleaning plant, which requires special mention, is the ease of access to the inside of machines and accessory plant, so that they may be efficiently cleaned. One of the greatest difficulties in a seed cleaning-plant is to prevent the remixing of the various seeds after they have been separated. Machines and plant must be thoroughly cleaned and brushed out when changing from one type of seed to another. Therefore machines should have removable doors, worm conveyors should have detachable bottoms, bins should contain no ledges or cracks, and bucket elevators should be avoided as much as possible. For these reasons pneumatic conveying has considerable advantages for seed-cleaning plants because it not only prevents the collection of different seeds and impurities in elevator buckets and worm conveyors, but it reduces dust in the atmosphere.

Similarly care should be taken to see that all sacks are thoroughly cleaned after use. Finally, the farmer can be of considerable help to the seed merchant in seeing that threshing machines and combined harvesters are very carefully cleaned after processing each type of seed.

Chapter VIII

CONDITIONING AND DRYING

CONDITIONING IN COMPOUND MILLS

GRAIN conditioning, as performed by conditioners in flour mills, does not exist in compound mills. A simple form of grain conditioning is carried out for specific purposes in some circumstances later explained, but conditioning in compound milling mainly refers to the application of water or steam to meals depending on whether they are to be sold as straights or compounds or cubed and pelleted.

The success of the gradual reduction roller mill system in flour milling largely depends on the attainment of that ideal condition in the wheat, which is essential to make a clean separation of the endosperm, from which the flour is made, from the rest of the grain. In compound milling, however, no separation is required since the whole grain is used for animal feeding; there is, therefore, no object in grain conditioning, except in the few cases referred to; in fact, in the compound process grain conditioning in any form is not only unnecessary but is usually harmful because the addition of moisture to grain blinds the screens of high speed percussion grinders and results in reduced capacity, sweating and increased evaporation loss; further, it toughens the husk, sets up greater frictional resistance, and increases the power consumption.

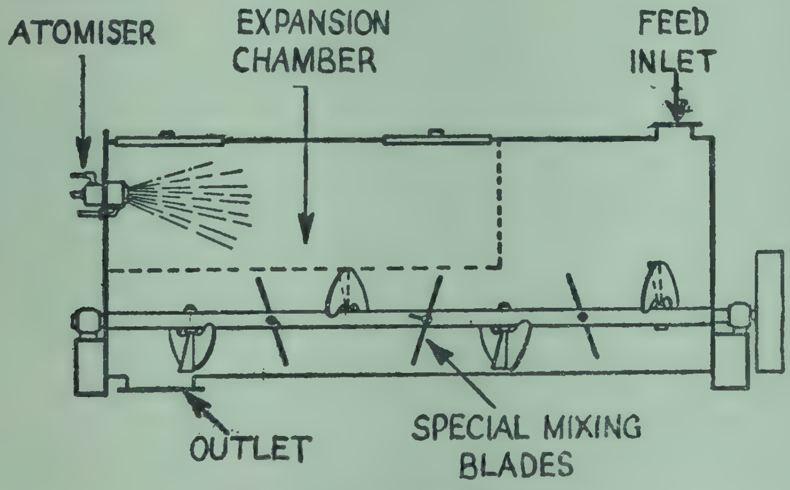


FIG. 75.—Spraying plant.

Therefore, in the compound process, any addition of moisture should take place after grinding. In the manufacture of meals, either for use as 'straights' or admixture into compounds, the usual practice is to add water to the ground meal by means of the Loring Centricity Humidifier made by the Millers' Supply Co. Ltd. or by spraying plants (Fig. 75) in which water is injected into the meal with the aid of compressed air. Spraying plants are described in detail under the heading of Continuous Mixers in Chapter XI.

This moisture addition restores the high evaporation loss common to percussion grinders which, in bad conditions, may be as much as 3 per cent. of the total throughout. If not restored, this is a serious loss of natural moisture and weight, particularly at present high prices. Limited moisture addition also improves the condition and quality of the meal and reduces dust in the atmosphere.

THE LORING CENTRICITY HUMIDIFIER

In this machine (Fig. 76), made by the Millers' Supply Co. Ltd., the water is fed through a glass tube and hollow spindle into perforated cages. The cages are attached to the lower end of the spindle and revolve at 1600-1800 r.p.m. The water is vaporised at this speed and is equally distributed around the cage into the meal.

A set of different sized tubes, marked with dots for various capacities, is supplied with the machine, the percentage of water being adjusted by changing the tube. The machine will deal with up to approximately 8 tons per hour of meal having an average weight of 30 lb. per cu. ft. The power required is 2 h.p. The illustration shows the machine fitted with an automatic water cut-off to ensure that no water is fed into the machine when the meal runs off.

In many compound mills, however, in which all or nearly all the output is in the form of cubes and pellets, water added by humidifiers or spraying plants is unnecessary because the meal is sufficiently conditioned by the steam used as part of the cubing and pelleting process. However, when particularly dry materials are being cubed and pelleted, such as grass meal, water is added, preferably as soon after grinding as possible, as well as steam, partly for the reasons previously given and partly to assist the cubing and pelleting action.

In the case of molassed compound meals, steam is often used because it assists the injection of molasses into the meal and also because it is more convenient to use steam in the same way as in the cubing plant. This method, however, raises the problem of cooling the meal and therefore, when manufacturing molassed meals in large quantities and as a separate product to cubes, it is better to spray the molasses by means of compressed air rather than with steam. In the latter case water may be added by humidifiers or spraying plants.

A simple form of grain conditioning is, however, sometimes beneficial. As referred to at the beginning of this chapter, these cases mainly concern millers, who sometimes employ roller mills to produce finer quality straight meals for specific feeding purposes. In addition, some mills use stone and plate grinders for producing special meals as, for example, Sussex Ground Oats or maize meal. In each case conditioning then consists of the addition and assimilation of water by water wheel dampers and conditioning bins. The grain is allowed to condition for 12 hours or longer according to its nature; this assimilates the moisture throughout the grain sufficiently to enable the grinders to separate the endosperm from the husk, which results in a softer meal of brighter and more even texture.

Some types of grain, particularly Persian and Indian barleys, are dry and dusty and soak up a good deal of moisture which improves the quality

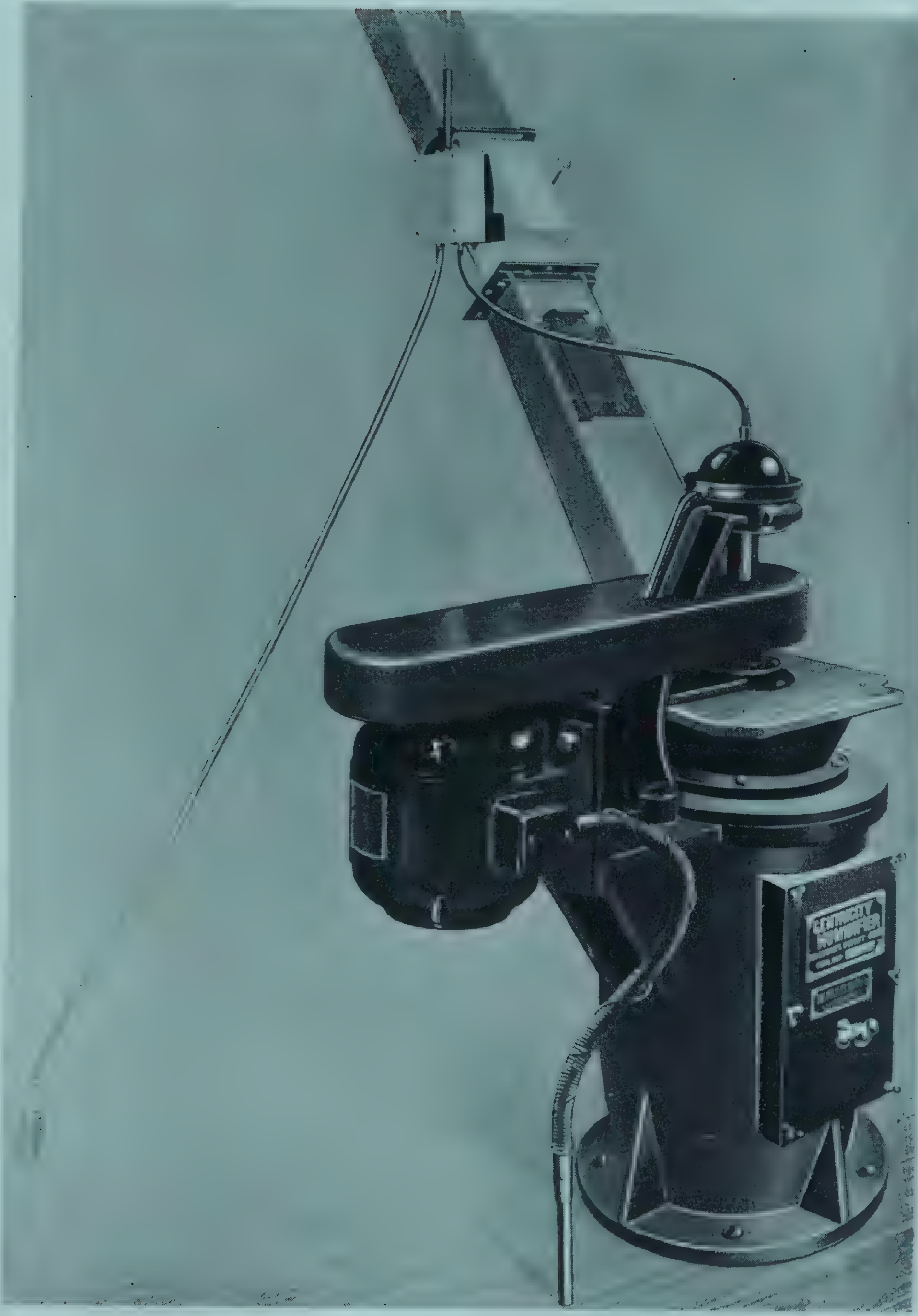

CENTRICITY HUMIDIFIER

FIG. 76.—Loring Centricity Humidifier.

and adds to the quantity of the meal. Moisture also restricts the large clouds of dust which make working conditions so unpleasant. With this type of grain, two or more dampings may be given with a standing period of 12 hours and upwards for each damping.

Water stoning machines as, for example, the Mersey Vat Stoner (Fig. 77), are used occasionally in these circumstances because, in addition to their function as dampers, they separate stones, which are frequently found in some types of barley and other grain; they work on the principle of water flotation in which the stones sink to the bottom of a cylinder, an upward current of water floating the lighter grain over the sides and at the same time washing off adhering dirt. The grain may then pass to a simple worm conveyor raised at an angle and fitted with a perforated bottom through which unabsorbed surface moisture drains off.

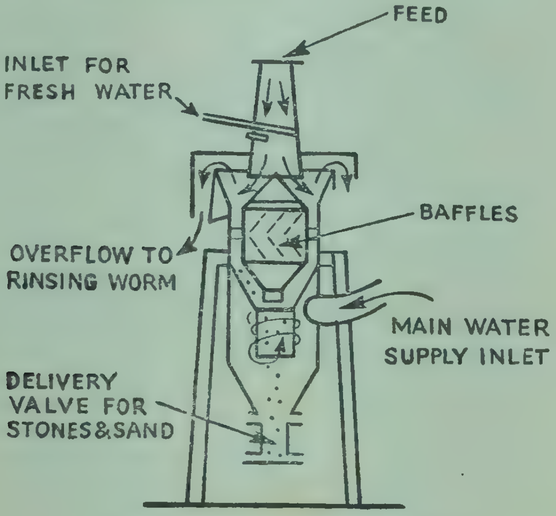


FIG. 77.—Mersey vat stoner.

GRAIN DRYING

In order to store grain for long periods, the moisture content must be below the figure at which any deterioration of the grain might occur. English wheat, for example, cannot be stored in bulk with a moisture content of more than 16 per cent, or in sacks with more than about 18 per cent without a likelihood of it becoming heated or mouldy, and for safe bulk storage the moisture content has to be reduced to about 15 per cent maximum. Sometimes, as in the case of wheat to be milled into flour, the moisture content must be reduced to a still lower figure so that the washing and conditioning processes, which take place before milling, do not increase the final moisture content of the wheat to too high a figure.

The drying of grain is, therefore, an important feature in milling and allied industries. During the war, when the quantity of native grain being grown was considerably increased, government drying and storage centres were erected in the large wheat producing areas to deal with the extra influx. These are still in operation, and help considerably in preventing congestion at mills during the seasonal busy periods. Dryers are of great advantage to compound and provender millers who buy grain direct from the farm, although sometimes farmers use their own dryers to facilitate storage and to obtain a better price for their grain.

HOT AIR DRYERS

All hot air grain dryers work on the same general principle and the Simon Dryer (Fig. 78) may be taken as a typical example. A rectangular steel tower which may vary in height from about 20 to 45 feet according to capacity contains a number of horizontal ducts, open at the bottom. These are positioned at regular intervals across the width of the machine, and each nest of ducts is staggered in relation to the ones above and below in order that all the grain is uniformly treated as it passes down the machine. An automatic feed bucket operates in conjunction with a mechanical discharge gate. These combine to give a uniform movement of grain through the machine and keep it filled with grain. The machine is divided into three sections through which the wheat slowly descends taking about 2 to 3 hours before being delivered from the machine through the discharge gate.

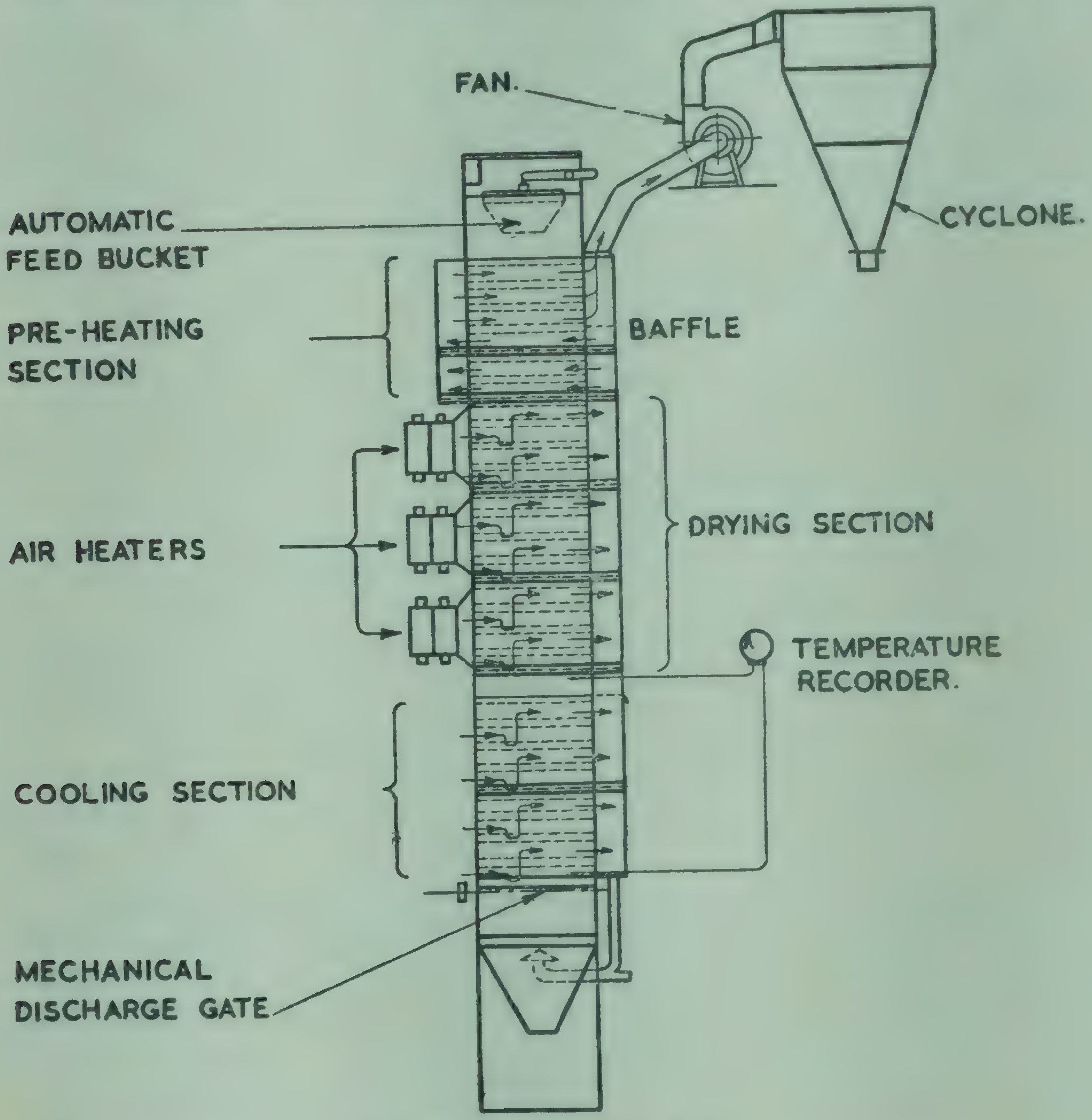

FAN.
AUTOMATIC FEED BUCKET
CYCLONE.
PRE-HEATING SECTION
BAFFLE
AIR HEATERS
DRYING SECTION
TEMPERATURE RECORDER.
COOLING SECTION
MECHANICAL DISCHARGE GATE

FIG. 78.—Simon hot-air dryer.

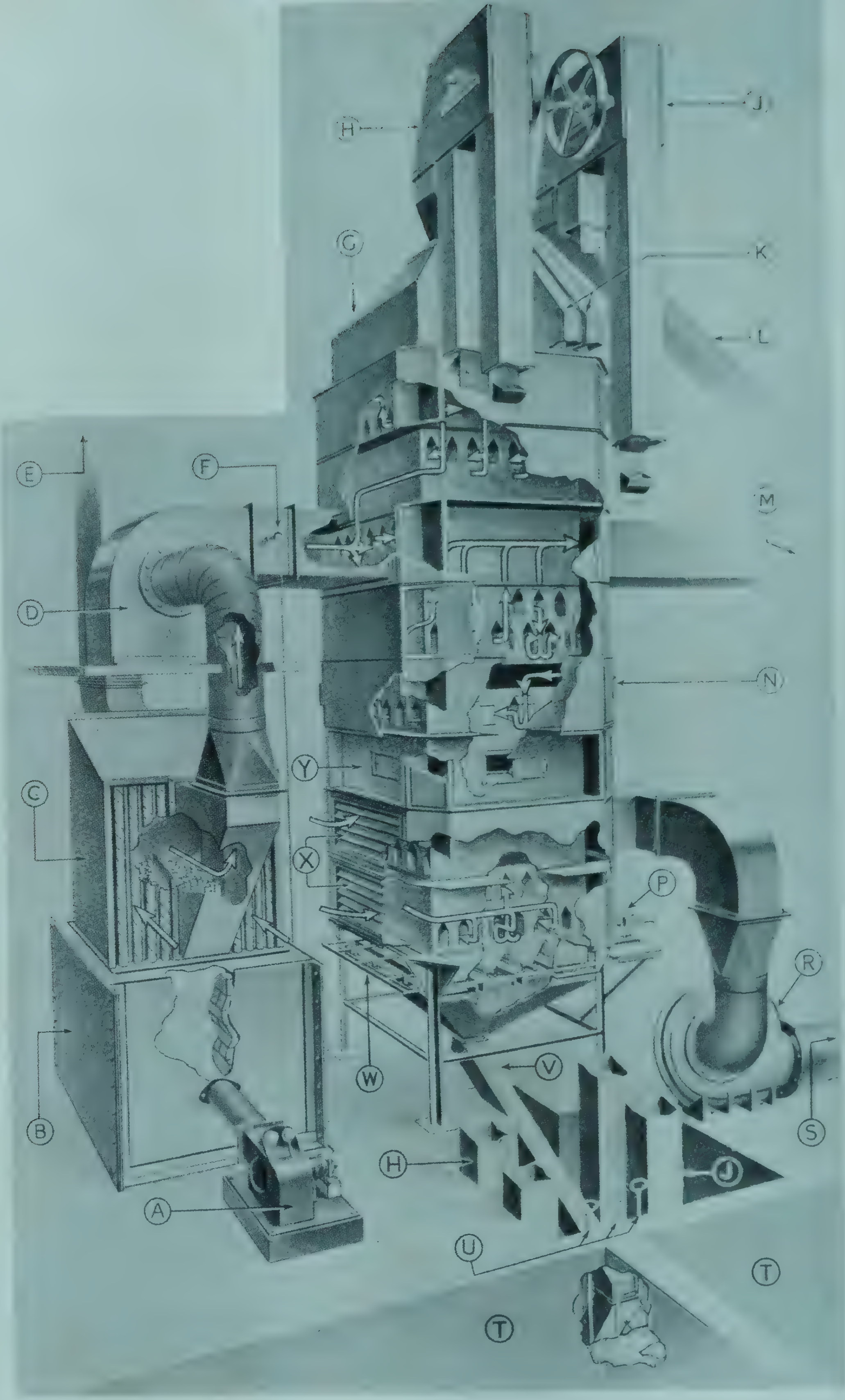


FIG. 79.—Aldersley dryer.

A. Pressure jet forced draught oil burner. B. Steel cased furnace chamber. C. Tubular pure air heater. D. Fan delivering hot air to dryer. E. Flue carrying furnace gases to atmosphere. F. Thermostat in hot air controlled by (A). G. Top hopper. H. Wet grain elevator feeding dryer. J. Dry grain elevator. K. Overflows. L. Dry grain chute to cleaner, storage, etc. M. Exhaust air from dryer to cyclone or atmosphere. N. Slides for inspection and cleaning. P. Patent reduction gear with hand control of (W). R. Cooling fan. S. Air available for pneumatic conveying where required. T. Wet grain intake hoppers. U. Feed controls to elevators. V. Dry grain chute to elevators. W. Grain discharge gear controlled by (P). X. Cold air inlet to cooling section. Y. Blank section forming air-seal between drying and cooling sections.

The first is the preheating section through which hot air from the drying and cooling sections is drawn. This raises the temperature of the wheat and causes the internal moisture in the grain to diffuse from the centre to the surface. No evaporation is required in this section so the ducts are arranged in order that the air does not pass through the mass of grain as in the drying and cooling sections, but simply gives up its heat to the grain by means of conduction through the duct walls.

In the drying section air is drawn through air heaters and into intermediate nests of ducts from which it finds its way through the grain to either of the nests of ducts above or below, which discharge the moisture laden air into the common trunking on the other side of the machine. With this arrangement, the hot air must pass through at least 24 in. of grain.

In the cooling section, air at atmospheric temperature is drawn through the grain in a similar manner to that in the drying section.

The most important factor in grain drying is to maintain a balance between the rate at which the moisture is evaporated from the surface to the atmosphere, and the rate at which the internal moisture is diffused to the surface. If the rate of evaporation exceeds the rate of diffusion, the surface of the grain becomes dry and relatively impervious to diffusion from the inside. This explains the need for a preheating and sweating section and care in the quantity and temperature of air used in the drying section. Otherwise the machine would become inefficient both in power consumption and performance.

The maximum safe temperature to which wheat may be raised is 115° F. when the wheat's moisture content is 17 per cent or over and 130° F. at less than 17 per cent. If the temperature of wheat rises above these figures there is danger of chemical changes taking place, particularly in the gluten.

The Porteous and Aldersley dryers are other machines which incorporate hot air. The Aldersley machine (Fig. 79) sometimes incorporates an air flow circuit in which the drying air is recirculated at a high degree of humidity first through the grain in the ' sweating ', or pre-heating, section and finally through tubes in a radiator section. These features are covered by patents.

RADIATOR AND HOT AIR DRYERS

As water is a much better conductor of heat than air, grain may be heated more easily and economically by means of hot water radiators than by hot air. As, however, in the majority of cases, the dryer is only used periodically, the advantages to be gained by employing hot water radiators do not always outweigh the extra initial cost of the machine plus the necessary water heating equipment.

Hot water radiators are used very extensively in almost all makes of conditioners in which accurate control of temperature and condition are essential.

E. R. & F. Turner, Ltd., manufacture a machine in which the whole of the pre-heating section consists of radiators and which can be used either as a dryer for native grain or as a conditioner. In this machine the grain moves gradually downwards through two columns or legs of perforated sheet metal. In the drying section hot air is blown between these columns by a fan from a steam heater and passes outwards through the grain; it then rises inside the casing to the outlet at the top of the machine. The drying section is divided into a number of compartments so that the quantity of air in each may be independently regulated.

The water in the pre-heating or radiator section is heated by the injection of live steam, the temperature being thermostatically controlled. The makers claim that this avoids any possibility of the grain becoming overheated. The cooling section is partitioned off from the drying section, cold air being blown through it by another fan. The grain is finally discharged through a rotary gate which can be adjusted to control the speed of the grain passing through the machine.

Moisture-laden air is used for conditioning purposes when the machine is used as a conditioner, and extra trunking is provided so that an air belt is formed which can be regulated to obtain any degree of saturation.

The temperature and quantity of air in grain dryers may be varied to suit different types of grain and an automatic temperature recorder may be fitted to the drying and cooling sections.

Chapter IX

GRINDERS

GRINDERS may be placed in four categories :

1. *Stone Grinders or Mill Stones*
    - (*a*) Horizontal grinders or ' Hursting Mills ' :
        - (i) The top-runner type.
        - (ii) The under-runner type.
    - (*b*) Vertical grinders.
2. *Attrition Grinders*
    - (*a*) Grinders with one revolving and one fixed disc.
    - (*b*) Grinders with both discs revolving.
3. *Percussion Grinders or Disintegrators*
    - (*a*) Single stage grinders with rigid beaters.
    - (*b*) Multi-stage grinders with rigid or semi-rigid beaters.
    - (*c*) Single stage grinders or Hammer Mills with free-swinging beaters.
4. *Roller Mills*

1. STONE GRINDERS OR MILL STONES

(*a*) HORIZONTAL STONE GRINDERS OR ' HURSTING MILLS '.

Horizontal stone grinders have now been almost entirely superseded by the more modern vertical type. The appearance and texture of products ground on horizontal machines are often of better quality, but this single advantage is far outweighed by the many other advantages of the vertical grinder. One of the greatest disadvantages of horizontal stones is that they require more frequent and expert dressing than the vertical type, and it is growing increasingly difficult to find experienced men for this work.

(i) *The top-runner type*

In this type the speed of the upper revolving stone is only about 150-180 r.p.m. and consequently it has a very low capacity. The grinding adjustment is hard to regulate as the pressure is derived from the weight of the revolving stone.

(ii) *The under-runner type*

This type is the more popular of the two and is still used occasionally in some small mills. The stones are usually smaller than the top-runner type so that the stock does not take so long to reach the circumference or skirt. The under-runner stone revolves at about 300 r.p.m. and the capacity is therefore greater than the other type. In addition, the grinding action is controlled by mechanical means. This type of grinder is manufactured as a twin unit by Messrs. W. S. Barron & Son Ltd.

(*b*) Vertical Stone Grinders

The advantages of vertical stone grinders over the horizontal types may be briefly summarised :

(1) In modern mills it is usually much more convenient to operate a horizontal shaft than a vertical one.
(2) Larger capacity for any size of stone chiefly owing to the higher speeds at which vertical machines may be driven.
(3) Easier stone ' dressing ' owing to the simpler furrow arrangement of the composition stones which are usually used with vertical mills.
(4) The improved feed box of the vertical mill.
(5) The greater accessibility, lower maintenance costs and smaller floor space required.

The Barron ' Dreadnought ' Grinder (Figs. 80 and 81) is an example of the vertical type. In this machine the runner stone is mounted on a horizontal shaft supported on three ring-oiling bearings, the grinding pressure

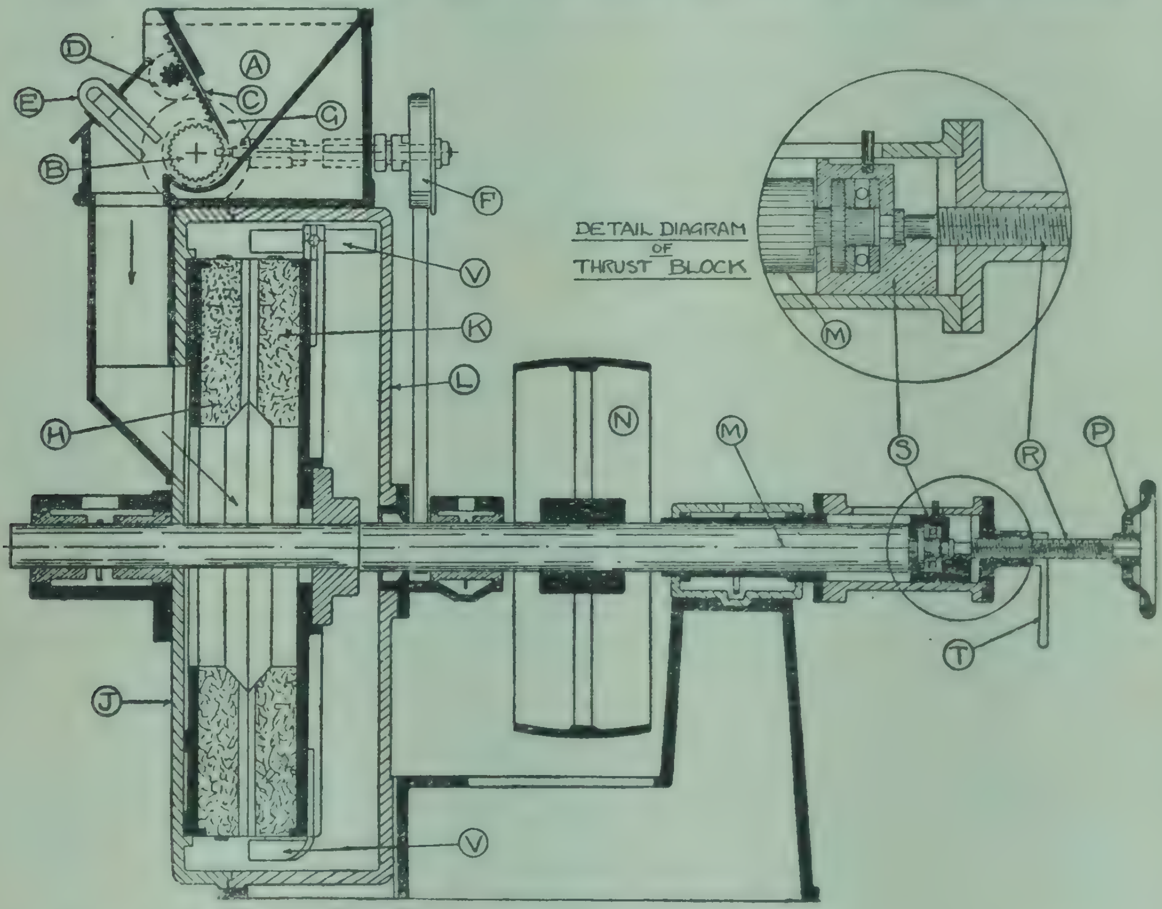


Fig. 80.—Barron ' Dreadnought ' grinder.

A. Feed hopper. B. Feed roll. C. Sliding plate to control feed. D. Small hand wheel operating feed plate pinion and rack. E. Magnets in feed spout. F. Driving pulley operating feed roll B through bevel gear G. G. Bevel gear driving feed roll. H. Fixed stone and plate. J. Fixed stone casing. K. Runner stone and plate, keyed to driving shaft. L. Runner stone casing. M. Driving shaft (secured to runner stone). N. Driving pulley. P. Handwheel to adjust distance between stones. R. Pressure screw. S. Sliding thrust block (a collar on the main shaft is housed in this block, the whole unit being moved along by rotation of pressure screw.) T. Locking nut with handle. U. Scrapers secured to runner stone collecting and guiding ground material to outlet.

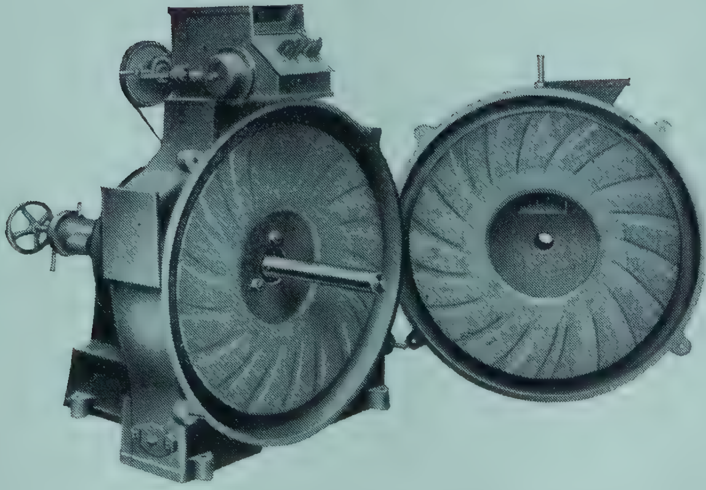


FIG. 81.—Barron 'Dreadnought' grinder.

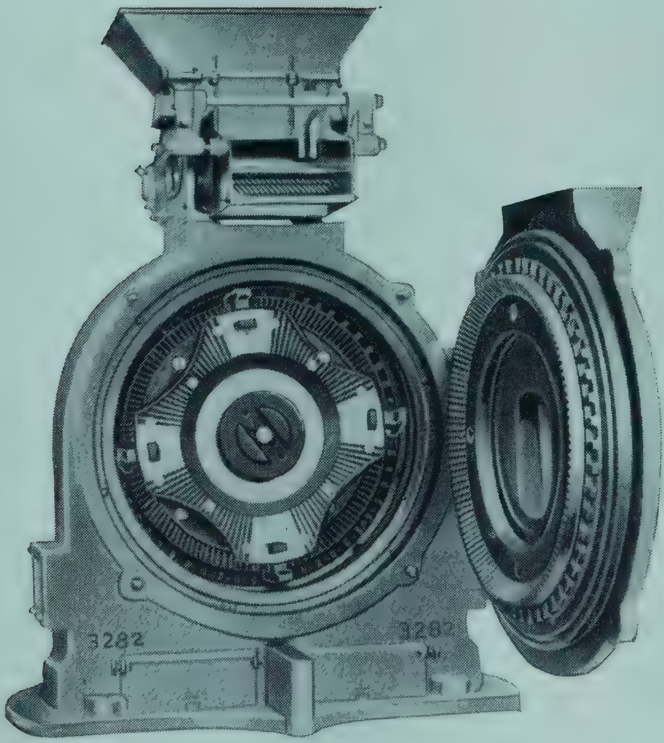


FIG. 85B.—Barron 'Impact' (D type) grinder.

being regulated by a threaded bolt which bears against a thrust bearing at the end of the driving shaft. The bolt is screwed in or out by the hand wheel which moves the runner stone towards or away from the fixed stone. Coil springs are inserted between the bolt and shaft to allow the stones to spring apart if an obstruction enters. The stock enters the machine over a feed roll driven from the stone shaft by a pulley through a pair of bevel gears. A clutch is fitted so that the feed can be stopped as required. The Barron machine may be supplied in several sizes, the stones varying from 12 in. to 3 ft. in diameter and the speed of the runner stone varying from 750 r.p.m. in the smallest size to 500 r.p.m. in the largest.

Another machine of this type is the ‘Juggernaut’ grinder made by E. R. & F. Turner Ltd. It works on the same principle as the ‘Dreadnought’ but differs in certain details. In this machine roller bearings replace the ring-oiling bearings of the Barron machine and a shaker tray, driven by an eccentric, replaces the feed roll.

The machine is exhausted by air entering through ducts fitted in the casing, which is caught by radial vanes on the back of the runner stone; it is freely circulated, finally leaving the machine at the stock discharge outlet.

Another vertical stone grinder is the ‘H & H’ shelling mill, made by Henry Simon Ltd., which was primarily designed for oat shelling but may also be used for other purposes. The stones are 3 ft. in diameter and are made of special composition; they are adjusted by means of a handwheel and screwed spindle, a second handwheel being provided for locking purposes.

Stone grinders are the most suitable for the manufacture of a soft, floury meal owing to their ‘cushioning’ action as distinct from the more granular meal made by an impact or percussion grinder. The quality of the ground product can be regulated by fitting stones of varying sharpness and durability. For example, natural stones are softer than composition stones and give a more floury meal, but leave a coarser husk. These conditions are required for whole wheatmeal flour and explain why the former are sometimes used for this purpose. Composition stones, on the other hand, are more uniform in hardness and are self sharpening owing to the numerous cutting edges of the small embedded particles of the composition. They are, therefore, more suitable for grinding tough husk to a fine degree as, for example, when grinding Sussex Ground Oats.

Stone grinders, although initially inexpensive and able to produce good quality meals, have a comparatively high power consumption, a very small capacity and high maintenance costs in relation to percussion machines; they are, therefore, very seldom used in the manufacture of the compound ration because of the much higher outputs and the more granular and uniform meals provided by the latter.

KINDS OF STONE

The history of grinding by attrition between stones dates from the very earliest times but is of little practical interest to the modern miller. In present times the only kinds of stone that are used are:

1. Natural stones.
   (*a*) French Burr. (*b*) Derbyshire Peak.
2. Artificial or Composition Stones.

Natural stones, which originate from quarries in districts from which they take their name, are no longer extensively used for milling. French Burr, which is composed mainly of silica but also contains other constituents to give it the necessary abrasive quality, is used mainly for grinding cork, pigments, etc. Derbyshire Peak, which is a form of sand-stone, is also quarried in Wales and on the Continent, and, although it produces a softer meal, it has poor abrasive qualities and is used even less than French Burr.

Derbyshire stones are quarried in one piece but French Burr are built up in sections. These sections are arranged either radially or in a ring round a circular centre piece according to the size available. A steel band is heated and shrunk round the periphery to prevent the pieces flying apart, and a backing of cement, which is levelled off to a smooth surface, is then added to obtain the required thickness of stone. Balance boxes are sunk into the cement to receive lead in the subsequent balancing process.

Composition stones are generally used by millers in modern vertical stone grinders; they may contain emery, granulated French Burr, corundum, quartz, electrite, grit silez and aloxite. Either a combination or any one of these substances may be mixed in varying proportions with magnesite cement to make up the necessary hardness depending on the type of work to be performed. The mixture is poured in liquid form on to cast-iron backplates having undercut grooves which hold the composition in place when it is set. The backing is then made up with cement in the same way as with natural stones.

Composition stones are used in preference to natural stones for a number of reasons :

1. They have a uniform hardness and have no soft spots as are sometimes found in natural stones.
2. The method of construction stiffens the stone and enables it to be used until the composition portion is almost entirely worn away; it also simplifies the changing of the stones and the method of mounting them on the driving shaft of the grinder.
3. They are self-sharpening owing to the large number of cutting edges presented by the small embedded particles.
4. The amount of skilled attention required for ' dressing ', is reduced. Redressing is only necessary after approximately 100 tons of material have been ground, the amount varying according to the type of material. For example, it is customary to redress or refurrow the Barron 36 in. ' Dreadnought ' Grinder after 80 tons of either maize or barley have been ground.
5. They have a greater capacity for a given horse power.

STONE BALANCING

It is of the utmost importance that all stones should be properly balanced to eliminate vibration, uneven grinding and excessive wear caused through the stones wandering or wobbling whilst in motion. In the case of the stationary stone, it is only necessary to see that the surface is exactly level, but the runner stone presents more difficulties. The runner stone may be balanced perfectly correctly whilst stationary by the adjustment of the lead weights in the balance boxes, but when the stone revolves centrifugal force may upset the balance. Horizontal runner stones must, therefore, be spun and the weights adjusted again until they run true. This is often a tedious business but is essential if consistent work is to be obtained. Vertical runner stones are mounted on a horizontal spindle supported at each end on knife edges or rollers and the balance weights are then manipulated until the stones remain static in any position.

THE GRINDING FACE OF STONES

The grinding face of a stone (Fig. 82) consists of:

(1) The ' eye ' or centre through which the feed enters.
(2) The ' swallow ' or depression around the eye which allows the feed to pass between the two stones and assists in its even distribution.
(3) The furrows which distribute the feed outwards over the whole grinding surface and form air channels thereby keeping the stones and the stock cool.
(4) The ' land ' or flat surface of the stone between the furrows which does the actual grinding and which is sometimes pitted or cracked to give an improved grinding surface.

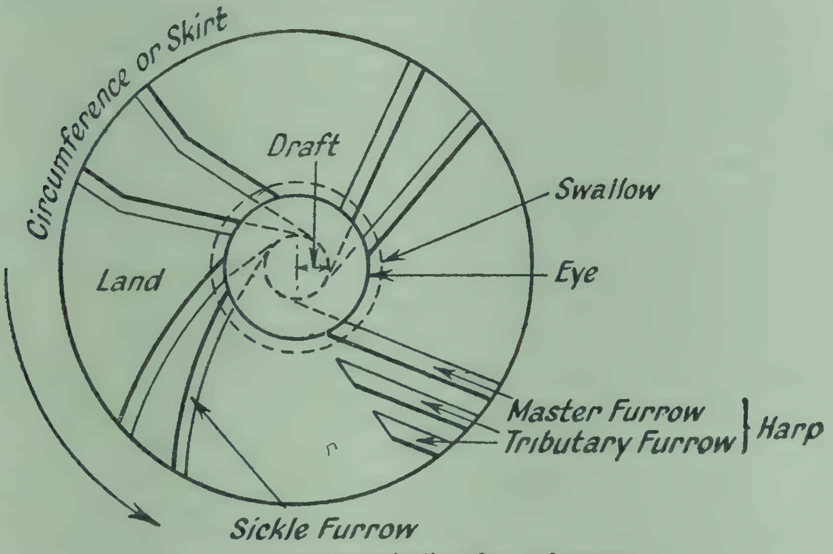


FIG. 82.—The grinding face of stones.

The amount of swallow and the number and shape of the furrows may vary with the kind of material to be ground and the degree of fineness required, although in modern practice these factors are largely standardised. It should be noted, however, that in general, the more numerous the furrows, the cooler the grinding and the greater the capacity. Furrows should have one vertical and one inclined or cutting edge, the correct term for the latter being the ' feather ' edge.

Various types of furrow are shown in Fig. 82. It should be noted that furrows do not run radially from the exact centre point of the stone to the circumference or ' skirt ', but start from the circumference of a circle slightly smaller than the eye. These furrows are known as master furrows. Tributary furrows are placed at an angle to the master furrow, and a master furrow with its tributary is known as a ' harp '. Sickle furrows are commonly used in modern vertical grinders. The radius of the small imaginary circle inside the eye from which the master furrows are drawn is known as the ' draft ' or lead of the furrows. The old idea was that the master furrow should have 1 in. of draft per foot of diameter of the stone but opinions now vary. The amount of draft and the arrangement of the furrows determines the path taken by the stock from the eye to the skirt and controls its distribution, grinding and discharge.

2. ATTRITION GRINDERS

Metal disc grinders were developed from the stone grinder; they work on the attrition principle and are similar in design to the vertical stone grinder, chilled iron plates taking the place of the stones. The object was to eliminate the skilled dressing, which stones require, and to increase the life of the grinding faces. The systems of one revolving and one fixed and of two revolving discs are both in use.

(*a*) Grinders with one Revolving and one Fixed Disc

An example of this type is the Turner ' Inkoos ' Grinder. The grinding pressure between the revolving and stationary discs is regulated in exactly the same way as with the ' Dreadnought ' and ' Juggernaut ' machines. The feed is controlled by a slide and enters the machine through a small hopper and eccentrically driven shaker tray. The discs have sickle-shaped grooves or furrows on both sides so that they can be reversed when worn.

A Barron ' Dreadnought ' grinder, known as the DP type, is fitted with metal discs in place of the stones as used with other types of ' Dreadnought '; this type of machine has a relatively higher output when grinding kibbled cake; it is also suitable for grinding kibbled maize and for grinding limestone into flour for mineral mixtures.

Owing to the minimum of skilled attention required, this type of grinder is very popular with farmers, corn merchants and small millers, but the capacity and uniformity of product is not usually sufficient for the larger compound miller.

(*b*) Grinders with Both Discs Revolving

An example of this type is the Turner ' Macrof ' grinder (Fig. 83) which has a much higher capacity and is, therefore, found in larger mills. Each disc is carried on a separate shaft which is mounted on roller bearings, the discs revolving in opposite directions. The direction of rotation of both discs may be periodically reversed in order to equalise the amount of wear and prolong their life. A set of inclined spokes at the centre of the right-hand disc carries the stock between the discs. The distance between the discs, which controls the degree of fineness of the meal, is adjusted by means of the bolts underneath the outer main bearings. The feed to the machine is regulated by a valve inside a cast-iron feed spout.

In this type of grinder, steel plates with thin, renewable grinding surfaces bolted to them, may be supplied instead of one-piece chilled iron discs which are more liable to break at the high speed at which they run. Each disc revolves at speeds from 1500 to 2500 r.p.m. giving a surface speed of 3000 to 5000 r.p.m. between the discs. The surface indentations vary in different types of machine but the pattern is not important.

Metal disc grinders, although generally described as attrition grinders, break up a certain amount of material by impact or percussion at the high speed at which it is thrown to and fro between the discs or plates. Control of particle size is thereby made difficult, because in this type of grinder there is no self-contained grading screen, as used on percussion grinders, to prevent the escape of material until it has been reduced to a uniform size.

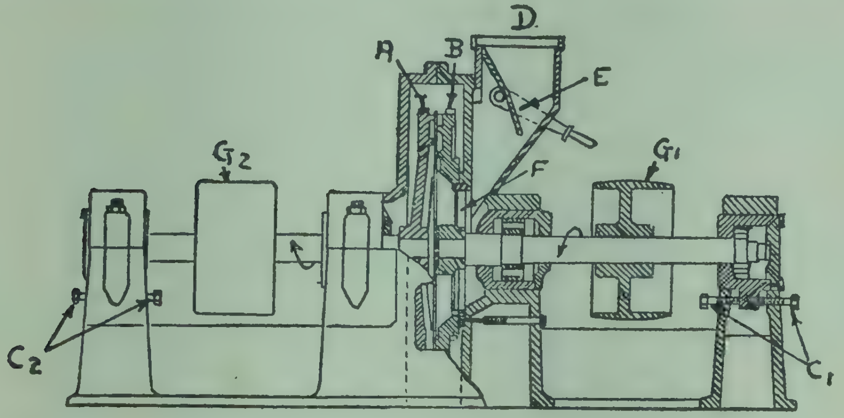


FIG. 83.—Turner ' Macrof ' grinder.
A and B. Grinding discs. C1 and C2. Set screws for axial adjustment to discs. D. Feed opening. E. Adjustable feed-gate. F. Inclined spokes. G1 and G2- Belt pulleys.

This weakness, which is experienced in most disc grinders, may be overcome by using some form of dressing machine to enable the coarser particles of material to be reground after the fines have been sieved out. When used under these conditions, disc grinders have a high capacity, especially on hard grain like maize for which they are particularly suitable. Power consumption is, however, apt to be high, which is a characteristic of attrition grinders.

3. PERCUSSION GRINDERS OR DISINTEGRATORS

Percussion grinders are by far the most popular type in use in compound mills. When dealing with raw materials of varying characteristics, they are the only type of grinder capable of giving in one operation the high capacity and uniformity of product necessary for compounding; they are easier to operate than other types and the changing of beaters and screens does not require the skilled labour which is necessary for the dressing of stones. The uniformity of product is controlled by the size of perforation of the interchangeable screens through which the material must pass before leaving the machine.

There are several forms of percussion grinders which are made by a number of manufacturers, but they may be grouped for consideration under three main types :

(*a*) SINGLE STAGE GRINDERS WITH RIGID BEATERS

This class is a development of the earliest principles of percussion grinding. Modern machines of this type usually have four beaters fixed to a shaft which rotates in a single grinding chamber fitted with a periphery screen.

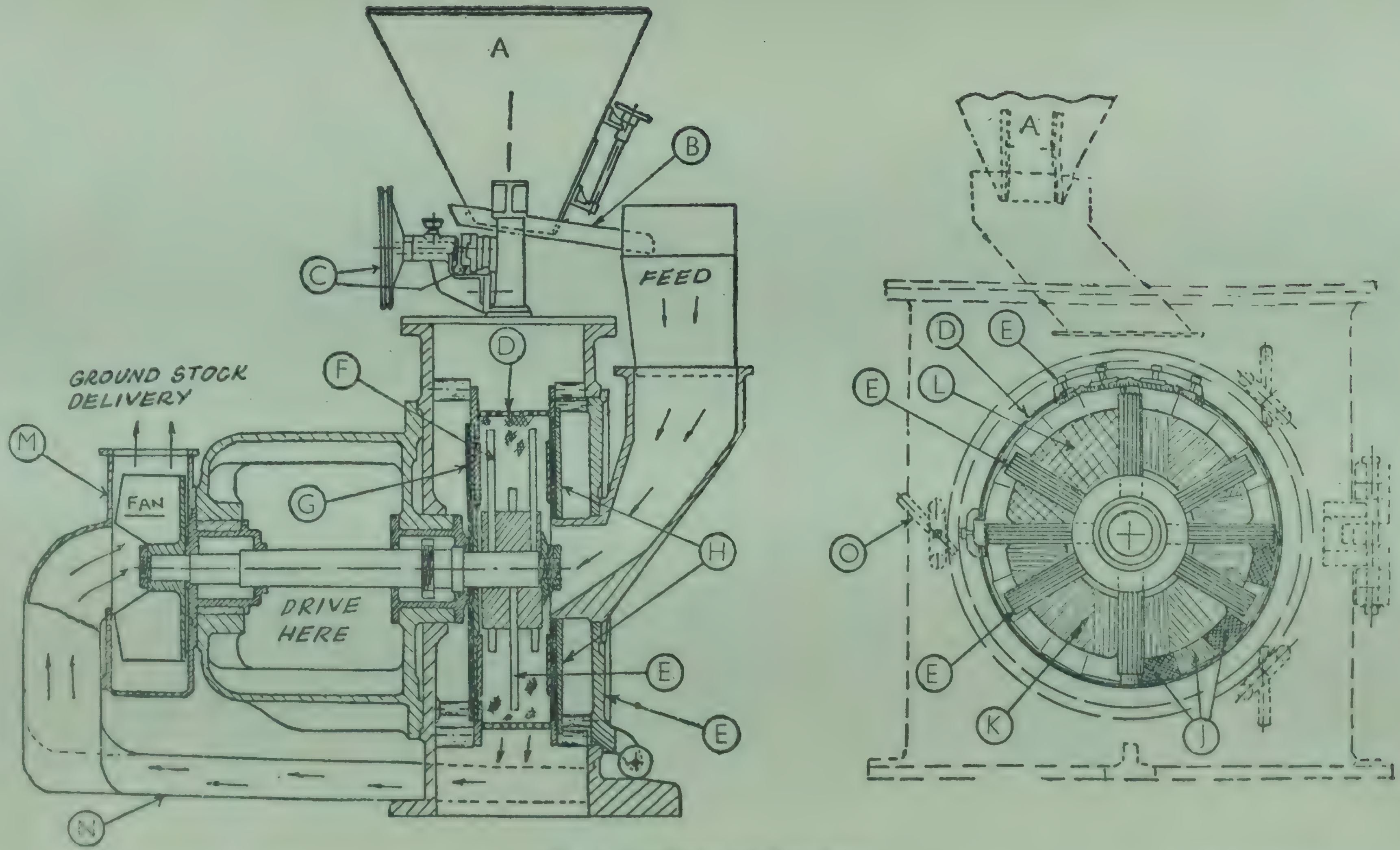

A
B
C
FEED
D
F
GROUND STOCK DELIVERY
M
FAN
G
H
DRIVE HERE
E
E
N
A
D
E
E
L
O
E
K
J

FIG. 84.—Porteous Premier grinder.

Key to diagram: (A) Feed hopper. (B) Shaker feed tray. (C) Eccentric mechanism operating feed tray. (D) Periphery screen. (E) Screen holder, with fluted pads attached to aid attrition. (F) Serrated flying beaters and screen. (G) Stationary back ring. (H) Stationary front ring. (J) Serrated pads on the front and back rings. (K) Additional serrated pads on the back ring. (L) Wire sieve (for air) on the front and back rings. (M) Fan body. (N) Suction trunk. (P) Swing door. (Q) Locking handles.

An example is the ‘ Premier ’ Grinder made by George Porteus & Son (Fig. 84). In this machine the material is fed into the centre of the grinding chamber through a feed chute, and the beaters, revolving at high speed, break up the particles of material and, at the same time, project them against the sides and periphery of the chamber, thereby giving them a second blow. The grinding action is assisted by serrations or corrugations fitted on both sides of the chamber which throw the particles back into the path of the beaters. This action is repeated until the particles are sufficiently reduced in size to pass through the periphery screen. The beaters and serrated sides, which are made of hardened steel, may be reversed when worn and are, of course, replaceable.

(*b*) MULTI-STAGE GRINDERS WITH RIGID OR SEMI-RIGID BEATERS

This class has a number of rigid or semi-rigid beaters fixed to a revolving shaft, but the material is ground in two or more stages as distinct from the single stage. All these types of grinders are particularly suitable for grinding coarse grains.

An example of this class is the Barron ‘ Impact ’ (D type) Grinder (Figs. 85 A and B). In this machine a feed hopper, controlled by a slide, delivers to a shaker tray fitted with a coarse screen which overtails foreign matter; the shaker is driven by a separate motor operating on an eccentric shaft. The feed is delivered to the centre of the grinding section which contains two stationary grinding rings consisting of a series of fixed, corrugated beaters or pins. A perforated screen completely surrounds the grinding rings, but, in older types, the rings only extend to about four-fifths of the circumference of the grinding chamber. In recent types, the grinding rings extend over the whole circumference of the grinding chamber. Two beaters, revolving at 3000-4000 r.p.m., reduce the material in the inner grinding chamber which is formed by the stationary inner ring: this is the first stage. In the second stage, the material escapes through the gap in the inner ring into the outer grinding chamber where the two outer beaters, revolving on the same shaft, grind the material against the outer ring until it is sufficiently reduced to pass through the perforated screen.

The beaters or pins, are made of manganese steel or high carbon alloy to resist the severe abrasive action of some of the materials that are ground. The machine may be driven by a built-in motor or a motor through a vee belt drive.

In the No. 3 and 4 sizes of machine, a recent development is that the beaters are designed for a certain freedom of movement and are referred to as semi-rigid; they are reversible and have four alternative grinding faces, the No. 3 machine being of ‘ H ’ section and the No. 4 of ‘ T ’ section. Sizes Nos. 0, 1 and 2 are fitted with rigid beaters as these are more suitable than the foregoing for smaller diameter grinding chambers.

The ‘ Perplex ’ is another machine of this class but of earlier origin. The ‘ Perplex ’ contains three grinding chambers formed by rings in which the gaps are evenly distributed throughout the whole periphery instead of in one place, as in the case of the ‘ Impact ’. The revolving beaters or pins are of similar pattern to the stationary pins so that the material passes evenly throughout the whole circumference of the inner grinding chamber.

The most recent example of the two-stage percussion grinder is the Barron (E Type) 'Impact' (Fig. 86). The design of this machine departs materially from that of the standard D type.

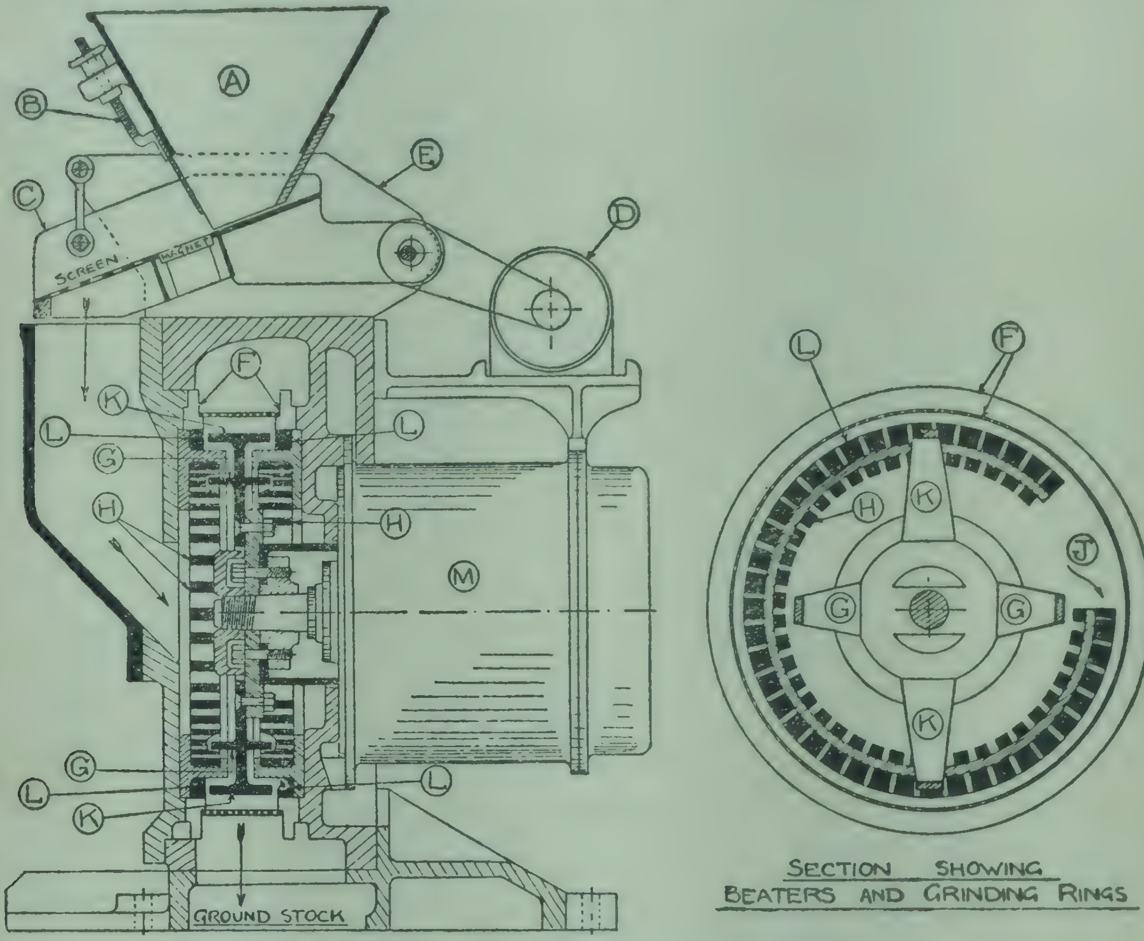


FIG. 85A.—Barron 'Impact' (D type) grinder.

Key to diagram: A. Feed hopper. B. Slide with screw adjustment to regulate the feed opening. C. Feed shaker, provided with a coarse screen to overtail large material. This shaker, suspended from the frame E, is reciprocated by a separate motor operating an eccentric shaft. D. Small motor driving feed shaker. E. Frame, housing feed shaker. F. Screen and screen ring. The screen extends right round the grinding rings. All ground stock passes through the screen and is designed to assist in reducing the stock. G. Two inner beaters—rapidly revolving. H. Stationary inner grinding ring. The inner beaters G, working against this inner ring, give a preliminary kibbling to the stock and then drive it through the opening shown at J into the grinding chamber proper. J. Opening to grinding chamber proper. K. Two outer beaters, grinding the stock against the outer grinding ring L and the screen, through which it is forced when sufficiently reduced. L. Stationary outer grinding rings. M. Built-in motor driving the beaters (on No. 2D type of machine this is a 20 h.p. motor running at 3000 r.p.m.).

The machine incorporates a suction magnet feed spout embodied in the cover or door. The feed passes over three permanent magnet plates of a powerful type and the suction generated by the grinder draws in the feed from the lower magnet plate, leaving behind any tramp metal on the magnets.

The first or preliminary grinding stage is performed by a group of four beaters working inside a fixed grinding ring, the ring having slots to allow passage of the ground material into the main grinding chamber. The four

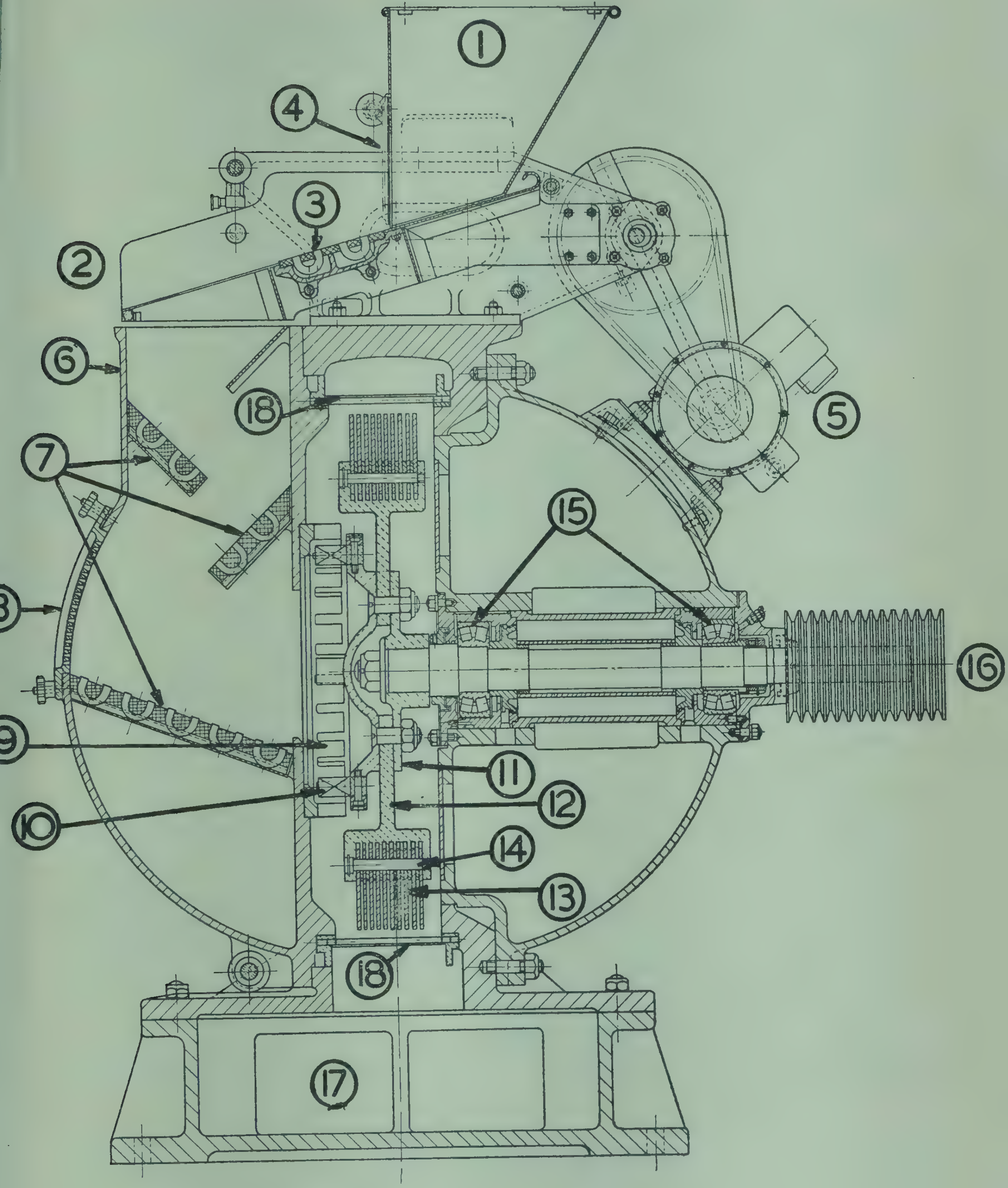


FIG. 86.—Barron 'Impact' (E type) grinder.

1. Feed hopper. 2. Reciprocating feed chute. 3. Magnet plate. 4. Feed control slide. 5. Auto
control. 6. Feed spout. 7. Feed spout magnets. 8. Breaker grid. 9. Fixed grinding ring.
10. Preliminary beaters. 11. Runner plate. 12. Becker holders. 13. Loose swing beaters.
14. Quick release pin. 15. Main bearing assembly. 16. Vee drive. 17. Circular baseplate.
18. Circular dressing screen.

preliminary beaters are held in position by screws in such a manner that replacement of the beaters can be effected with the aid of a screwdriver only.

After passing through the first stage, the feed is distributed evenly throughout the main grinder chamber by a series of four rotating beaters, each having ten loose swing beaters attached to them. These beaters are reversible at their tips and also reversible end for end, so that each beater has four cutting or wearing surfaces. Here, too, beaters are replaced with the aid of a screwdriver only.

The shaft and grinding members are contained on large diameter roller bearings housed as a self-contained unit inside the circular body of the machine. Ground stock passing through the screen is delivered through the bottom of the grinder. The machine is mounted on a circular baseplate, which can be turned to suit any angle when pneumatic delivery is used.

The grinder is normally supplied complete with ball-bearing shaker feed, or alternatively it can be provided with a rotary type feeder. Both feeders are arranged with Westmatic Auto Control to govern output and power consumption. The machine also incorporates a special design of pneumatic delivery. All Pneumatic Delivery Systems from grinders are described in Chapter XIX.

(*c*) SINGLE-STAGE GRINDERS WITH FREE SWINGING BEATERS OR HAMMERS, KNOWN AS HAMMER MILLS

This class of machine is particularly popular amongst compound millers as an all-purpose grinder. There are many variations in detail but the essential feature is that the beaters are pivoted to a revolving shaft in such a way that they are free to swing through an arc which is limited to their plane of rotation. They are, therefore, commonly referred to as ‘ Swing ’ hammer mills.

An advantage of hammer mills is that in the event of the entry of a foreign body, such as a nut or bolt, less damage is liable to be caused than in a machine of the rigid beater type; usually the worst result is the bursting of a screen which can be easily replaced. In addition, hammer mills produce a more uniform product from a wider range of materials than other types of grinders. For example, hammer mills can deal with slab cakes and cut green crops as well as coarse grains.

The two main types of hammer mills are :

(1) The large type known as pulverisers.
(2) The smaller type which are fitted with automatic shaker feeders, sloping trays or worm feeders.

The pulveriser shown in cross-section (Fig. 87) is chiefly used for grinding slab oil cakes, the width of the feed inlet being designed to take the slabs without any previous reduction on a kibbling machine. If, however, a kibbling machine is installed the feed to the pulveriser will be more constant, with resultant benefits in power consumption, capacity and evenness of grinding. Alternatively a fly wheel may be fitted to the grinder shaft, which creates a certain reserve of power when the machine is running light, and offsets the sudden load when the slabs are dropped one by one into the path of the beaters.

As illustrated, pulverisers are fitted with a metal trap to receive foreign bodies, such as nuts and bolts, which may accidentally enter the machine, and which are projected into the trap by the revolving beaters. The lower half of the machine is fitted with a perforated screen or frame fitted with bars; the upper half is fitted with breaker blocks with serrated surfaces which deflect the material back into the path of the beaters as in the case of the ' Premier ' Grinder. The machine (Fig. 87) is made by Christy and Norris Ltd. The ' Gannow ' is another of similar type.

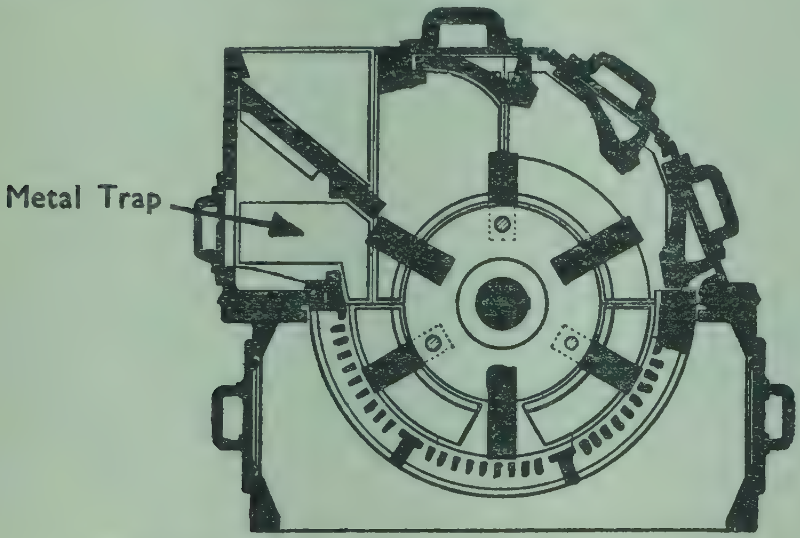


FIG. 87.—Grinder cross-section showing metal trap.

The second type of mill is made by a large number of manufacturers and in a number of sizes; the machines made by Christy and Norris Ltd. (Figs. 88A and B) are good examples of this class. In this machine a shaker feeder may be fitted, which gives a good adjustment over a wide range of materials. Alternatively, a worm feeder for use with light or non-free-running materials, or a tray feeder working on the gravity principle for grain, may be fitted.

The grinding chamber is formed by a series of circular steel plates or discs built up on a shaft and separated sufficiently to allow the beaters or hammers to be mounted between them upon transverse spindles or pins, which pass through the beaters near their outer edge. Unlike the pulveriser, the perforated screen surrounds the beaters except at the point where the feed enters the machine. A hinged cover allows for easy access to the grinding chambers. It should be noted that in all hammer mills the feed enters the machine at some point on the periphery and not at the centre or ' eye ', as with other types of grinders.

The work of the hammer mill is controlled by adjusting the speed of the beaters, which may be between 14,000 and 20,000 ft. per minute, and the distance between the beaters and the perforated screen which, in the case of the ' Briton ', is between $\frac{1}{4}$ and $1\frac{1}{4}$ in. High speeds and small clearances give a fine grind and slower speeds and larger clearances a coarser grind. The steel plates or discs are drilled with holes at various distances so that the clearance can be easily set by inserting the pins in the position desired. For compounding purposes, very fine grinding is not required and the clearances should not be smaller than necessary as a wider clearance reduces power consumption.

Hammer type beaters are made of manganese steel and can be reversed when the tips have worn on one side. They may be of plain rectangular shape or they may have the corners cut into a series of steps so as to give a larger number of cutting edges. The tips may be made of stellite steel to resist abrasion, but it should be noted that stellite is non-magnetic and care should be taken with its use.

Another example, known as the Rotary Pulveriser, is made by W. S. Barron & Son Ltd. (Fig. 89). This machine combines some of the points described in both of the above types of mills. It is fitted with a hinged cover, thus allowing for easy changing of beaters and screens, the screen surrounding the bottom half of the beater assembly; the top half consists of breaker bars and a metal pocket for collecting tramp iron.

In conjunction with these features, the machine has the wide feed opening of the larger type of hammer mill so that a variety of materials may be fed into it by means of a band conveyor or chute. The machine is particularly suitable for grinding bulky materials, such as roots, dried lucerne and grass.

PERCUSSION GRINDER FEED CONTROL UNITS AND FEEDERS

The object of grinder controls is to maintain the feed to the grinder automatically within close limits of its optimum output, thus ensuring the most economical use of power. This method eliminates the human element and avoids the tendency of operators to set the grinder feed below maximum in order to prevent any possibility of a sudden overload cutting out the motor. Most high speed grinders now incorporate automatic feed controls.

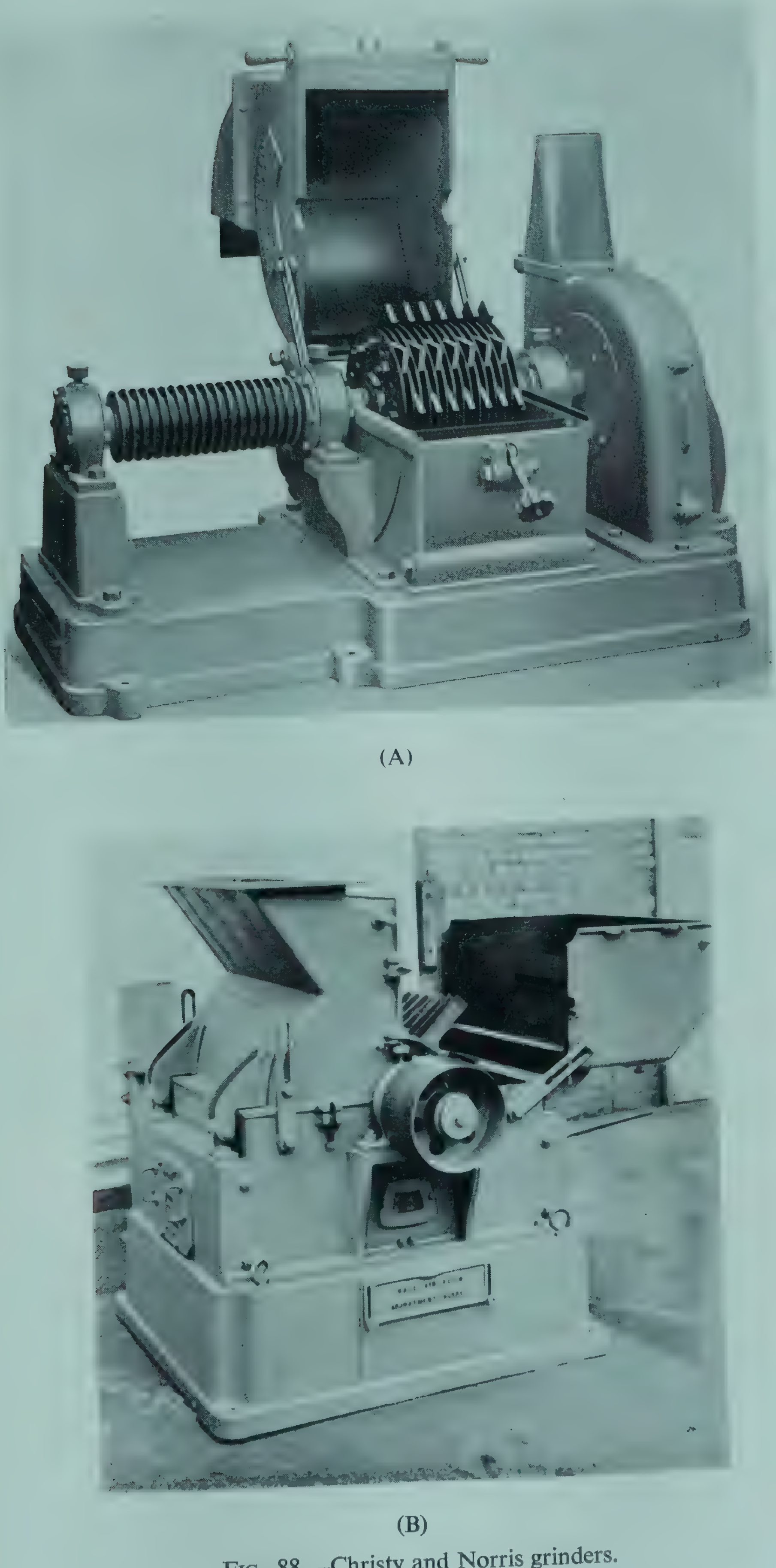
A typical example is the Barron Westmatic Feed control unit (Figs. 90A & B) as fitted to ' Impact ' grinders. In the past, standard practice has been to operate the shaker or rotary feeder of the ' Impact ' grinders either by whittle belt from the grinder shaft or, alternatively, from a separately mounted fractional h.p. motor.

In this method the feeder runs at a constant speed and the quantity or volume of feed entering the grinder is determined by the operator. By fitting the automatic control unit, however, any increase or decrease in the current taken by the grinder motor automatically decreases or increases the speed of the feeder and, therefore, the quantity of material entering the grinder.

Instead of driving the feeder direct from the spindle of the fractional h.p. motor, a fan rotor is mounted on the motor spindle inside a circular drum. The drum rotates freely on its own bearings and mounted inside it, and attached to its two circular ends, are other fan rotors which have a running clearance against the revolving fan rotor.

On starting up the fractional h.p. motor, the circular drum and spindle gradually assume the same speed as the revolving fan rotor. The drive is transmitted by the air fluid or shearing effect between the revolving fan rotor and the two fixed fan rotors.

Surrounding the rotating drum is an aluminium cover on which is mounted a magnet and terminal box. The windings of the electro-magnet are in series with a small transformer connected in turn to the windings of



(A)

(B)

Fig. 88.—Christy and Norris grinders.

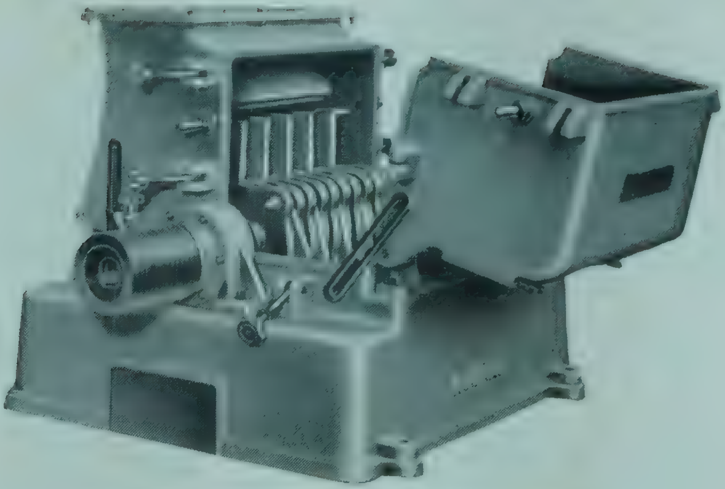


FIG. 89.—Barron rotary pulveriser.

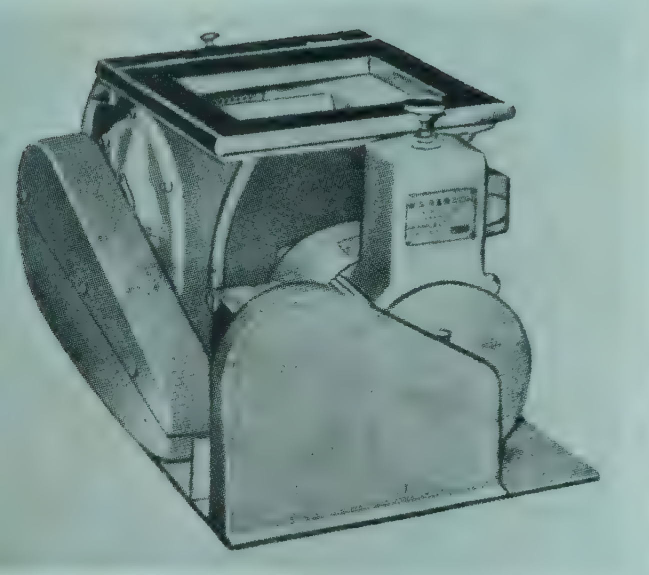


FIG. 90A.—Westmatic automatic grinder control.

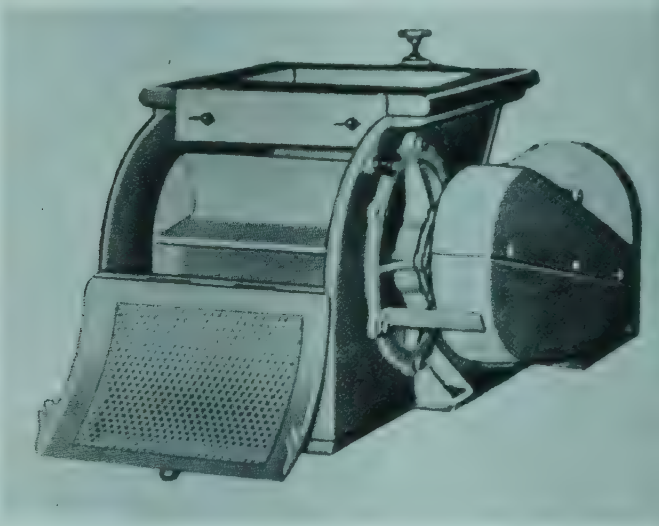


FIG. 90B.—Westmatic automatic grinder control.

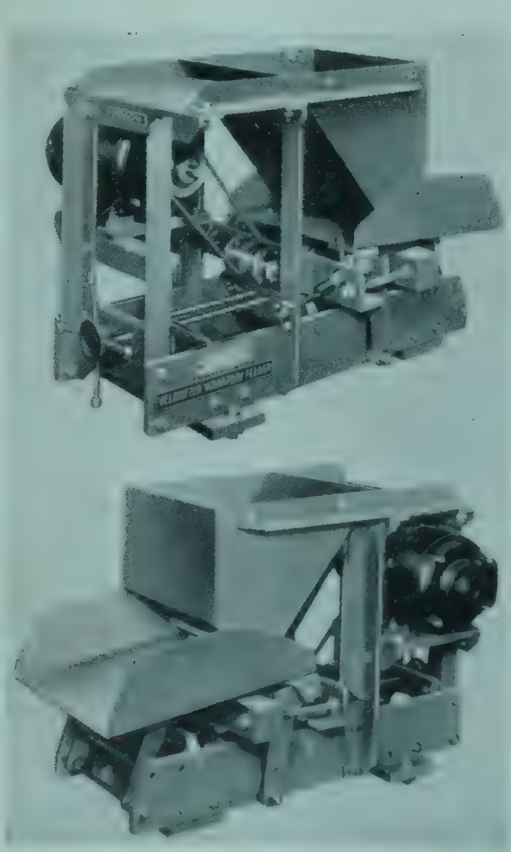


FIG. 91.—The Velofeeder

the main grinder motor. Therefore, any variation in the load on the main motor will react on the magnet which in turn creates a magnetic pull against the surface of the revolving drum. In other words, the speed of the drum, from which the feeder is operated, is entirely governed by the load on the main motor.

Additional adjustment and degrees of setting can be obtained by rotating an adjustable unit controlling the clearance between the magnet and the revolving drum. As there is no actual mechanical contact between the fixed and revolving fan rotors, the drive is silent in operation.

The Velofeeder (Fig. 91), manufactured by Henry Simon Ltd., although employed for a wide variety of feeding problems, is mainly used in compound mills in conjunction with high speed grinders. It is a mechanical vibrator feeder in which a new system of impact is utilised industrially for the first time. It is driven by a $\frac{1}{4}$ h.p. motor and can be regulated manually or automatically to produce a wide range of amplitudes from as much as $\frac{1}{4}$ in. down to zero, thus offering a wide range of delivery on almost any type of material.

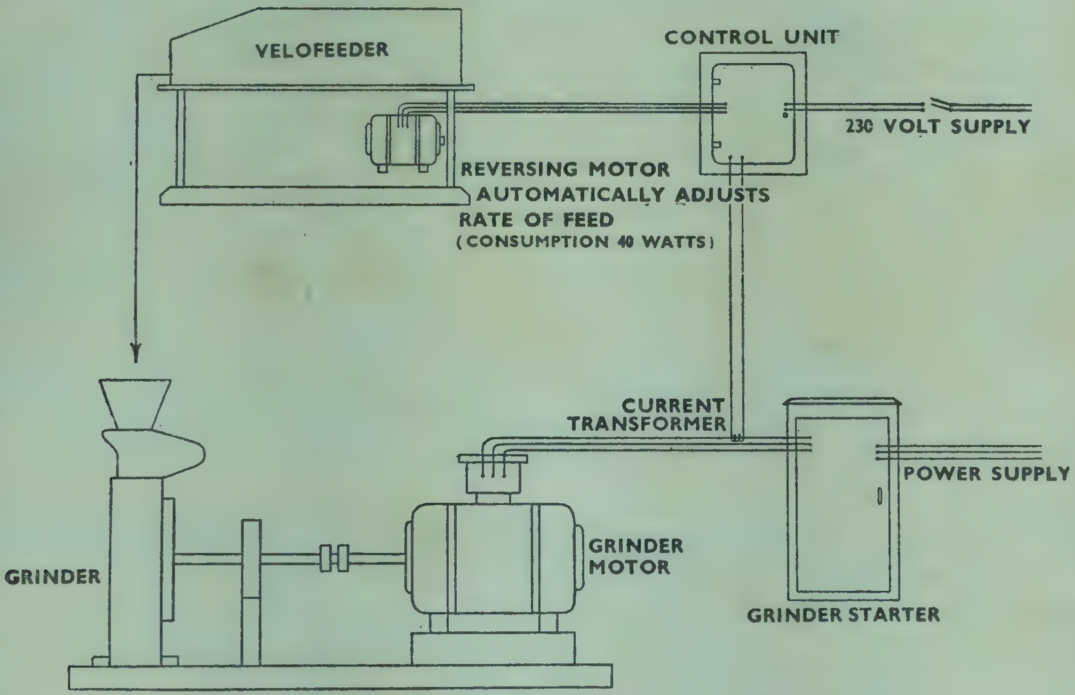

VELOFEEDER
CONTROL UNIT
230 VOLT SUPPLY
REVERSING MOTOR
AUTOMATICALLY ADJUSTS
RATE OF FEED
(CONSUMPTION 40 WATTS)
CURRENT
TRANSFORMER
POWER SUPPLY
GRINDER
MOTOR
GRINDER
GRINDER STARTER

FIG. 92.—The Velofeeder automatic grinder control unit.

Velofeeders are manufactured in three sizes with 12 in., 18 in. and 24 in. wide feed trays, and examples of its performance with a 12 in. tray are as follows :

Material	*Maximum Capacity per hour Tons*	*Minimum Capacity per hour Lb.*
Kibbled oilcake	10	60
Compound meal	9	50
Bran	4	30

The Velofeeder with special controller is widely used when a positive method of feed control is required to ensure 100% loading of a grinder independent of variations in the type and density of material being treated. Fig. 92 describes this method of control.

4. ROLLER MILLS

The roller mill will never replace the high speed grinder in compound or provender milling to any large extent, because the principle on which roller milling depends for its efficiency is that of gradual reduction. Even the simplest plant must consist of at least two or three distinct grinding operations and, to ensure one standard quality of product from the rolls, dressing equipment is essential. Any widespread use of roller mills in compound mills is, therefore, far too elaborate and costly because it entails the use of a number of machines and takes up too much space in relation to the high speed grinder.

Moreover, standard roller mill design does not lend itself to the handling of some materials as, for example, expeller flakes, and it is certainly not as adaptable as the all-purpose high-speed grinder, for dealing with the wide range of raw materials used in compound milling. Finally, the high quality meal produced by roller mills is not essential for compound manufacture.

For the grinding of 'straights', roller mills have been tried out in the past on quite a large scale but, in these cases, their main disadvantage—apart from the capital cost involved—is their inability, even with 'Collins' fluting, to cut the husks of Oats and Barley when the flutes are dull. To ensure that the flutes are kept sharp, the rolls have to be constantly changed with consequent heavy refluting costs. For example, in the case of Persian and Moroccan barley, the life of the flutes is a matter of weeks. Therefore, in a plant of this type, as described in the next chapter, further elaboration is necessary in the form of aspirators and high speed grinders, to separate and grind the husk.

On the other hand, particularly for the production of high quality straight meals from maize and similar grain of a low husk content and for other miscellaneous purposes, roller mills have certain distinct advantages which must be set against the disadvantages.

These advantages are :

(1) Low power consumption, which in some cases may mean a saving of up to 35 per cent.
(2) Cooler grinding, resulting in
    (*a*) A reduction of the evaporation loss from approximately 3 per cent to 1 per cent.
    (*b*) A lower temperature in the ground product whereby its keeping qualities are improved even though the moisture content may be higher.
(3) A meal of more even texture and brighter appearance.
(4) Improved grinding efficiency and quality of product because of grain conditioning (see Chapter VIII).

A modern diagonal roller mill, manufactured by Henry Simon Ltd., is illustrated in Fig. 93, with descriptive references. It should be noted that a roller mill consists of two separate units each having its own pair of rolls, feed, delivery, and drive. The rolls used for provender purposes are normally 40 in. or less in length and 10 in. in diameter; they are made of cast iron, chilled on the outside, and are geared to run in opposite directions. The differential speed between the top roll and the bottom is usually 2½ to 1 and, for provender purposes, the first break rolls are normally more coarsely fluted than in the break system of a flour mill. In the first break, when cracking whole maize and barley, the top roll has five and the bottom seven flutes to the inch.

The grinding action is performed not only by the pressure of the rolls but also by the cutting or scissor action of the flutes running spirally along the length of the roll. The angle of spiral, which is the same in each roll, is usually one in fourteen but in certain cases, as, for example, in bran grinding, the spiral may be given a shorter pitch, thus increasing the cutting or scissor action by causing the flutes in the two rolls to cross at a greater angle at the nip.

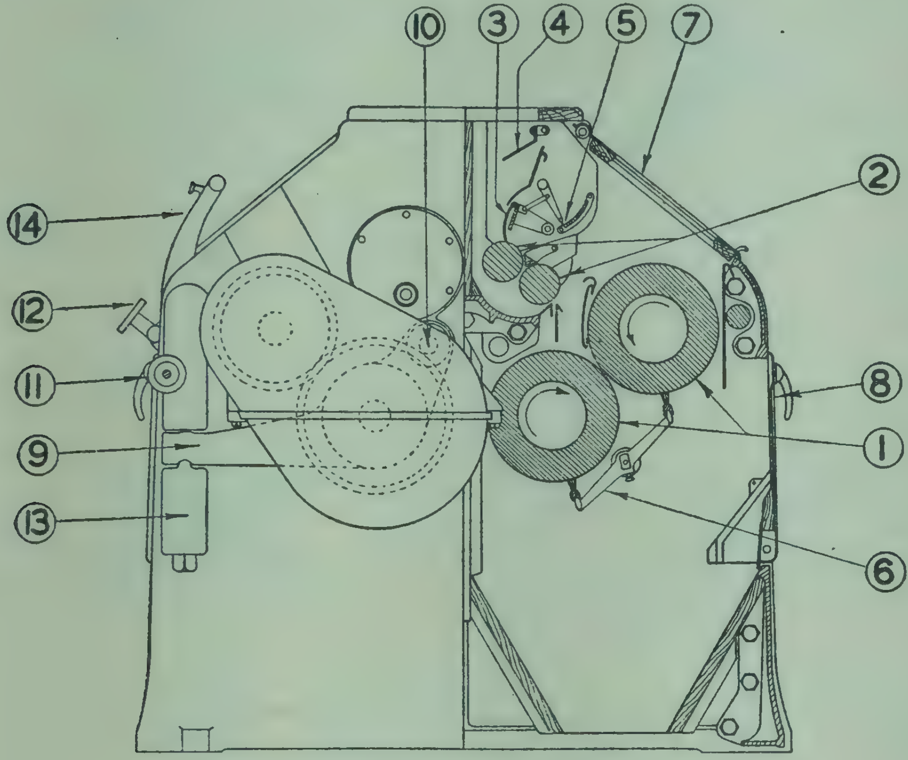
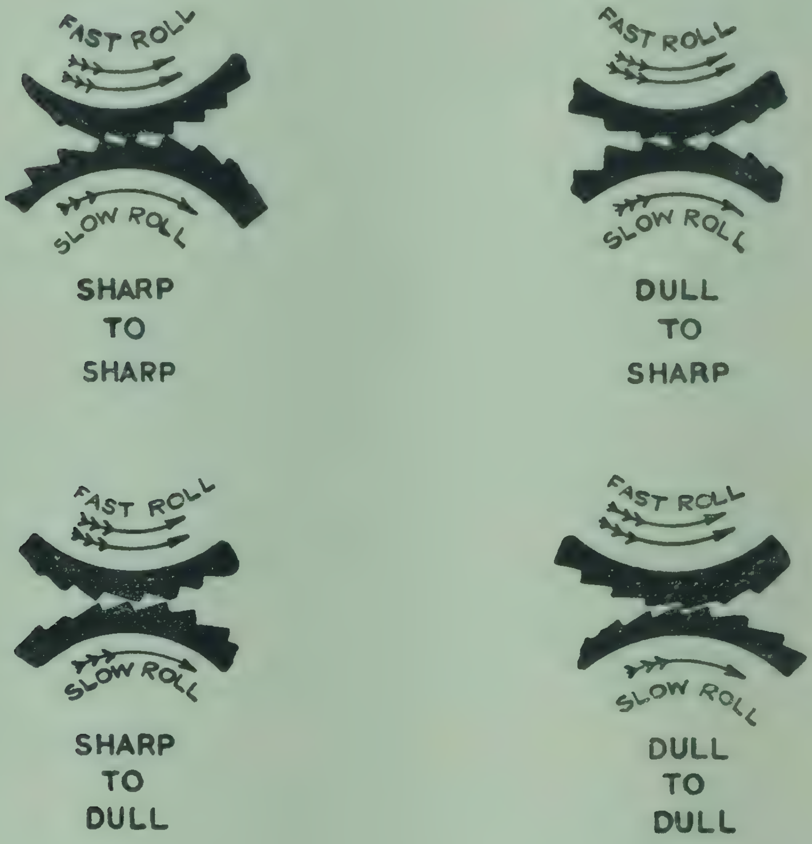


FIG. 93.—The Simon diagonal roller mill.

1. Roll body. 2. Fluted feed rolls. 3 and 4. Interconnected feed plates—movement of 4 under feed communicated to 3. 5. Pointer and scale for use with non-automatic operation. 6. Brush scrapers for roll cleaning. 7 and 8. Inspection doors. 9. Pivoted arm carrying lower roller. 10. Pivot of 9. 11 and 12. Position control for adjustable roll. 13. Spring to allow rolls to part in the event of obstruction. 14. Throw-out lever for quick release of rolls and cutting out feed.

For bran and husk grinding and other miscellaneous purposes, special fluting (Fig. 94), and also ‘ Collins ’ fluting, may be used; these types of fluting consist of some flutes and some land and are best suited for reducing the tough bran and germ of some cereals, for which purpose the rolls should be run so that the flutes on each roll face ‘ sharp to sharp ’ (Fig. 94). When grinding grits, however, a softer meal is produced when the flutes are ‘ dull to dull ’.

FLUTING ARRANGEMENTS FOR ROLLS.


FAST ROLL
SLOW ROLL
FAST ROLL
SLOW ROLL
FAST ROLL
SLOW ROLL
FAST ROLL
SLOW ROLL

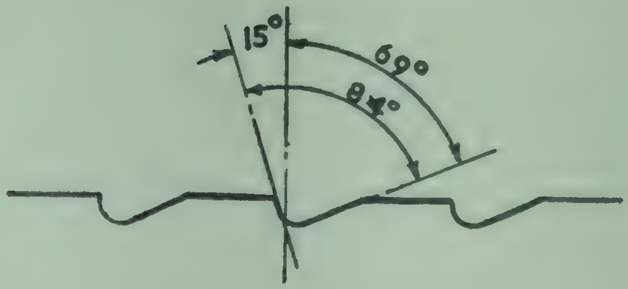
SHARP TO SHARP

DULL TO SHARP

SHARP TO DULL

DULL TO DULL

SPECIAL FLUTING FOR HUSK GRINDING.



24 FLUTES PER INCH.

Fig. 94.

W. S. Barron & Son Ltd. manufacture a horizontal roller mill for miscellaneous purposes which may have one to four pairs of rolls one above the other. In this machine, the rolls are usually of 9 in. diameter and 16 to 24 in. long. Each pair is driven separately through differential gears by a pulley running at 400-500 r.p.m. A small sieve is fitted over the top pair of rolls to extract foreign matter and, in some cases, a sieve may be fitted between each pair. This type of multiple-pair roller mill, although not often found in modern mills, has certain advantages for gradual reduction in one machine.

Chapter X

GRINDER PLANTS

THE various types of grinder plants and the purposes for which they are used may be placed in five categories :

1. *Single Operation Plants*
   (*a*) Standard percussion type for grain and oilcakes for use in compounds or as straights.
   (*b*) Percussion type for compounds after mixing.
2. *Double Operation Plants*
   (*a*) High capacity percussion type for oilcakes.
   (*b*) High capacity attrition and percussion type for coarse grains.
3. *Stone Grinder Plants*
   For high quality Barley Meal and Sussex Ground oats.
4. *Roller Mill Plants*
   Simple type for Maize Meal and Grits.
5. *Combined Stone, Roller Mill and Percussion Plants*
   Elaborate type for high quality straights.

1. SINGLE OPERATION PLANTS

(*a*) STANDARD PERCUSSION TYPE

In batch plants it is usual compound milling practice to grind before mixing. In semi-continuous and continuous plants materials may be ground before or after mixing. When grinding before mixing (Fig. 95), grain, oilcakes and sometimes miscellaneous products, are emptied into grinding bins or hoppers and are ground separately by percussion grinders; in batch plants, the ground products are used either as ‘ straights ’ or they are tipped by hand into batch mixers which mix them with the raw materials which do not require grinding; in semi-continuous and continuous plants, they are delivered either by bucket elevator or pneumatic plants to a range of process bins, some of which are allocated for the raw materials which do not require grinding.

A separate section of grinding bins and separate elevators are usually allocated for grain, oilcakes and miscellaneous materials respectively because grain is sometimes rough-cleaned and weighed, slab oil cakes are kibbled, and some miscellaneous products, for example, malt culms which are non-free flowing, are fed either from hoppers with agitators or from small mixers. Grain measurers and vibrator feeders are used for discharging grain and oilcakes respectively. More bins are allocated for grain than for oilcakes because of the larger number of grain varieties but, for the reasons given below, alternative runs should be provided from any bin to any grinder. Some millers prefer the fixed beater grinder for grain and the free swinging hammer mill for oilcakes, although both are suitable for either purpose.

For the reasons given in Chapter VIII, no conditioning is necessary in this plant except for moisture correction after grinding for ‘ straights ’.

Sizes of perforations in grinder screens vary according to the quality of the product required and the nature of the raw materials. When grinding oilcakes, maize and other similar grains, screens in the region of $\frac{1}{8}$ in. (3·2 mm.) mesh usually produce satisfactory meals for cubing purposes.

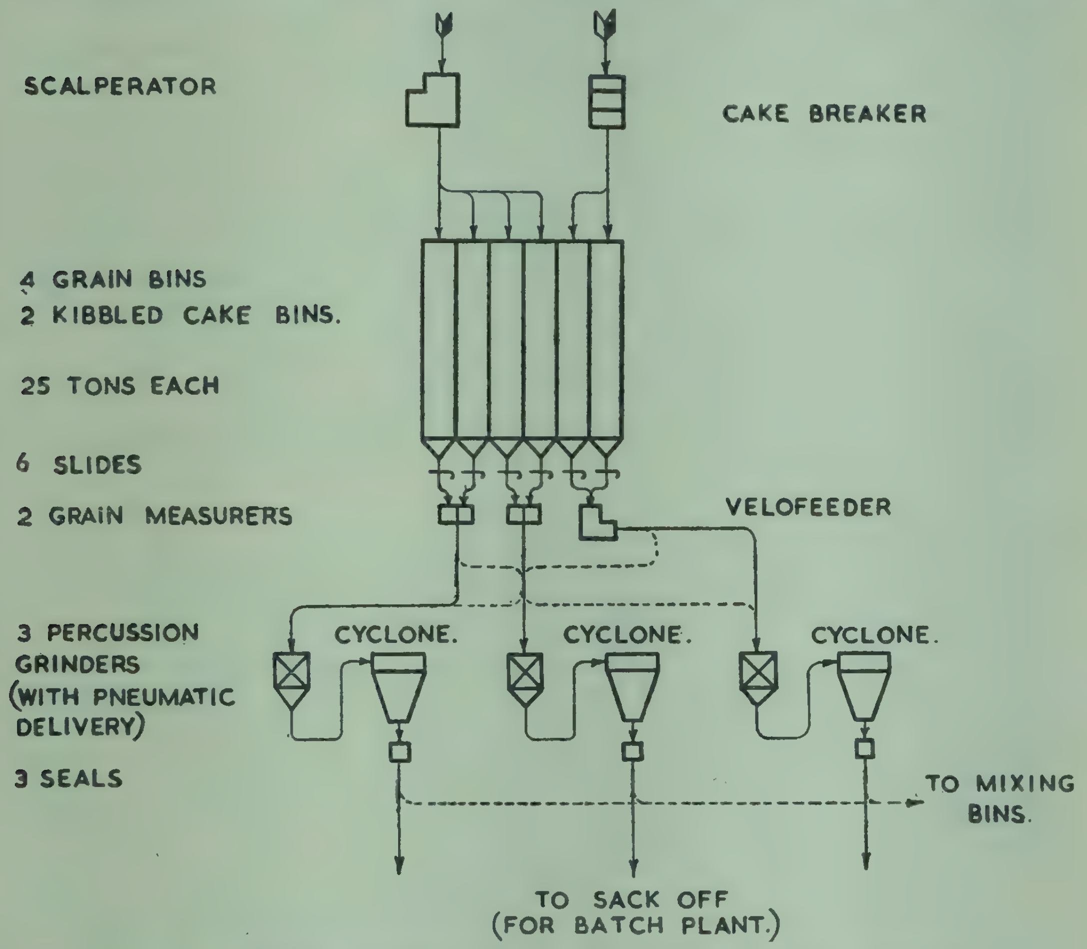

SCALPERATOR
CAKE BREAKER
4 GRAIN BINS
2 KIBBLED CAKE BINS.
25 TONS EACH
6 SLIDES
2 GRAIN MEASURERS
VELOFEEDER
3 PERCUSSION GRINDERS (WITH PNEUMATIC DELIVERY)
CYCLONE.
CYCLONE.
CYCLONE.
3 SEALS
TO MIXING BINS.
TO SACK OFF (FOR BATCH PLANT.)

FIG. 95.—Standard percussion grinder plant as used before mixing plant.

For cubing, screens should be as coarse as possible, whilst maintaining quality, in order to produce higher outputs from the grinder. Materials containing a high husk content, however, should not normally be ground through screens coarser than $\frac{1}{16}$ in. (1·6 mm.) mesh, particularly for pelleting. When pelleting, it is beneficial if most materials are ground through this same size of screen because, unless a dresser is available, this gives uniform particle size. For chick pellets, finer screens of $\frac{1}{24}$ in. (1 mm.) are more suitable.

It will be seen therefore, that it is advantageous, even in small mills, to have at least two or more grinders which can be fed from a number of bins, to make the plant flexible and to avoid screen changing as much as possible. As regards output, it may be taken that the limiting factor with any type of grinder is the rate or capacity at which the husk of the grain can be reduced.

Dressing machines, consisting of either high capacity sieves or centrifugals, which dress out the grinder throughs and return the overtails to the grinder, are at present not often used because the perforated grinder screen controls the particle size of the ground product sufficiently well for most requirements. However, it is interesting to note that they do offer additional advantages but, if they are installed in a plant of this type, provision must be made to by-pass them from the grinder because certain materials containing a large percentage of husk, for example, cotton seeds, choke the meshes and overtail most of the material to the grinder. When dressing machines are used, a No. 16 mesh cover for compounding or a No. 24-30 for ' straights ' is usual.

The advantages of dressing machines are :

(1) A safeguard in case of bursts in the grinder screen.
(2) Increase in grinder capacity because a coarser screen may be fitted to the grinder, the particle size of the ground product being controlled by the dressing machine. In this way, if an average size of screen, say a $\frac{3}{32}$ in. is selected, changing of screens may be largely avoided.
(3) More uniform particle size which increases the capacity of the cubing and pelleting machine.
(4) Brighter appearance of meal for ' straights ', particularly if a finer cover is fitted.

(*b*) Percussion Type for Compounds after Mixing

Many of the largest compound millers in this country grind some or all of their materials after they have been blended and mixed. Sometimes grain is coarsely pre-ground before mixing and re-ground after mixing with the remaining materials. In post-war port mills, however, there has been a tendency to grind all materials, including grain, in one operation after mixing, because it is well known that some kinds of grain, which are difficult to grind, such as oats and barley, are more readily ground when ground as a mixed ration with maize, kibbled cake, etc.

Another advantage of grinding all materials after mixing in continuous or semi-continuous compound plants, is that the layout is simplified by the elimination of a number of bins and elevating equipment as compared with plant (*a*). As explained in plant (*a*) grain and oilcakes are fed to storage or grinding bins and then after grinding to the process bins, but in plant (*b*) (Fig. 96) all the raw materials are fed direct to one range of bins from which they are blended, mixed and ground. It will, therefore, be seen that in plant (*a*) two bins are used for unground and ground materials for each kind of grain and oil cake, but in plant (*b*) only one is used.

An important advantage of grinding the mixed ration is that all the materials are reduced to a uniform particle size giving a more homogeneous mixture than is possible by separate grinding. As already mentioned, even texture increases the capacity of the cubing and pelleting operation and also improves the quality of the cubes and pellets.

On the other hand, in plant (*b*) buffer bins have to be used after mixing and there is the possibility of the mixed materials stratifying or grading in the bins which can, to some extent, undo the work of the mixers. Moreover, in plant (*b*) meals that do not require grinding must either pass through the grinders or be separated again after mixing by a sieve so that they by-pass the grinder and rejoin the rest of the compound afterwards. If they pass through the grinder, the power consumption is increased as compared with

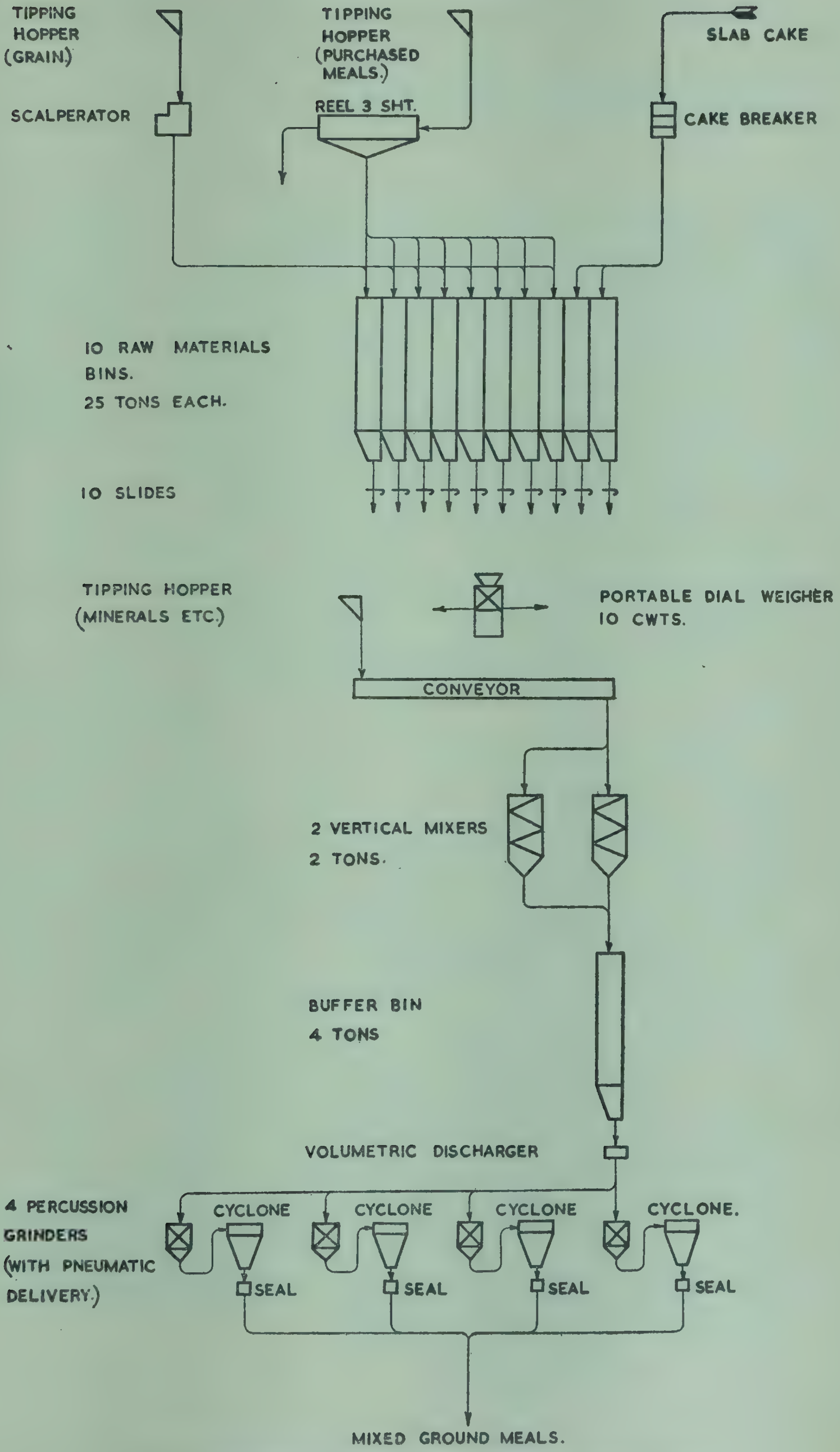

TIPPING HOPPER (GRAIN)
SCALPERATOR
TIPPING HOPPER (PURCHASED MEALS.)
REEL 3 SHT.
SLAB CAKE
CAKE BREAKER
10 RAW MATERIALS BINS.
25 TONS EACH.
10 SLIDES
TIPPING HOPPER (MINERALS ETC.)
PORTABLE DIAL WEIGHER
10 CWTS.
CONVEYOR
2 VERTICAL MIXERS
2 TONS.
BUFFER BIN
4 TONS
VOLUMETRIC DISCHARGER
4 PERCUSSION GRINDERS (WITH PNEUMATIC DELIVERY.)
CYCLONE
CYCLONE
CYCLONE
CYCLONE.
SEAL
SEAL
SEAL
SEAL
MIXED GROUND MEALS.

FIG. 96.—Percussion grinder plant as used after mixing plant.

plant (*a*), although the increase is not excessive. On the other hand, coarse meals benefit from being sized but, even if only the fine meals are separated and by-passed, the possibility of stratification is increased.

In most cases, when grinding after mixing, grinders are fitted with $\frac{1}{8}$ in. (3·2 mm.) screens and dressing machines with No. 16 mesh covers.

2. DOUBLE OPERATION PLANTS

(*a*) HIGH CAPACITY PERCUSSION TYPE FOR OILCAKES

Double operation plants give a higher capacity per horse-power and a better quality product compared with the single type, particularly when handling materials like slab oilcakes and coarse grains; they are, of course, more elaborate and are, therefore, not often found in compound mills except in the conditions referred to below.

Fig. 98 illustrates a plant suitable for millers who grind large quantities of slab oilcakes or expeller flakes direct from bags because of limited bin storage facilities; it has a capacity of 8-10 tons per hour of cake meals. In the first

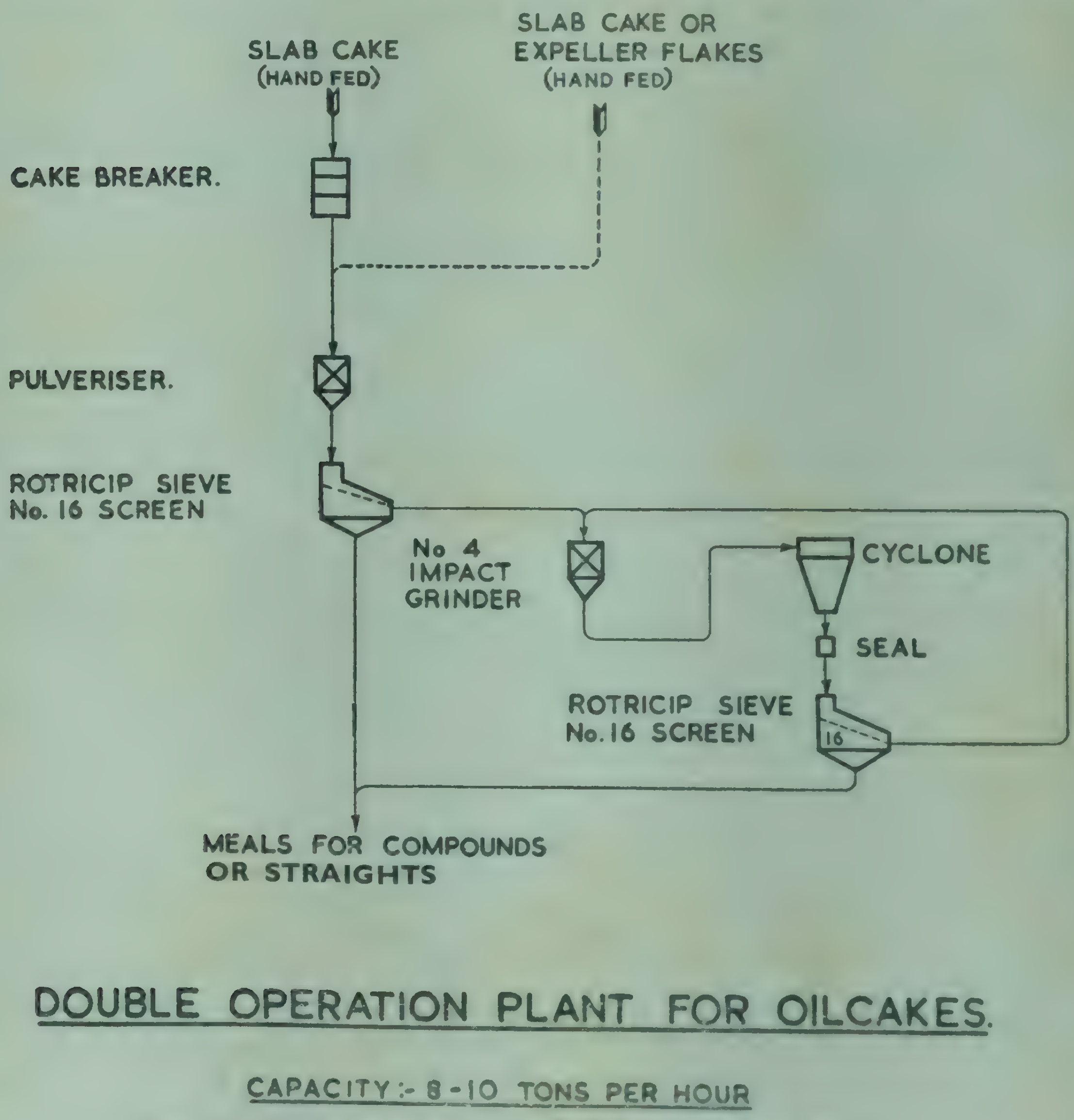

SLAB CAKE (HAND FED)
SLAB CAKE OR EXPELLER FLAKES (HAND FED)
CAKE BREAKER.
PULVERISER.
ROTRICIP SIEVE No. 16 SCREEN
No 4 IMPACT GRINDER
CYCLONE
SEAL
ROTRICIP SIEVE No. 16 SCREEN
16
MEALS FOR COMPOUNDS OR STRAIGHTS
DOUBLE OPERATION PLANT FOR OILCAKES.
CAPACITY :- 8 - 10 TONS PER HOUR

FIG. 98.—High capacity percussion grinder plant for oilcakes.

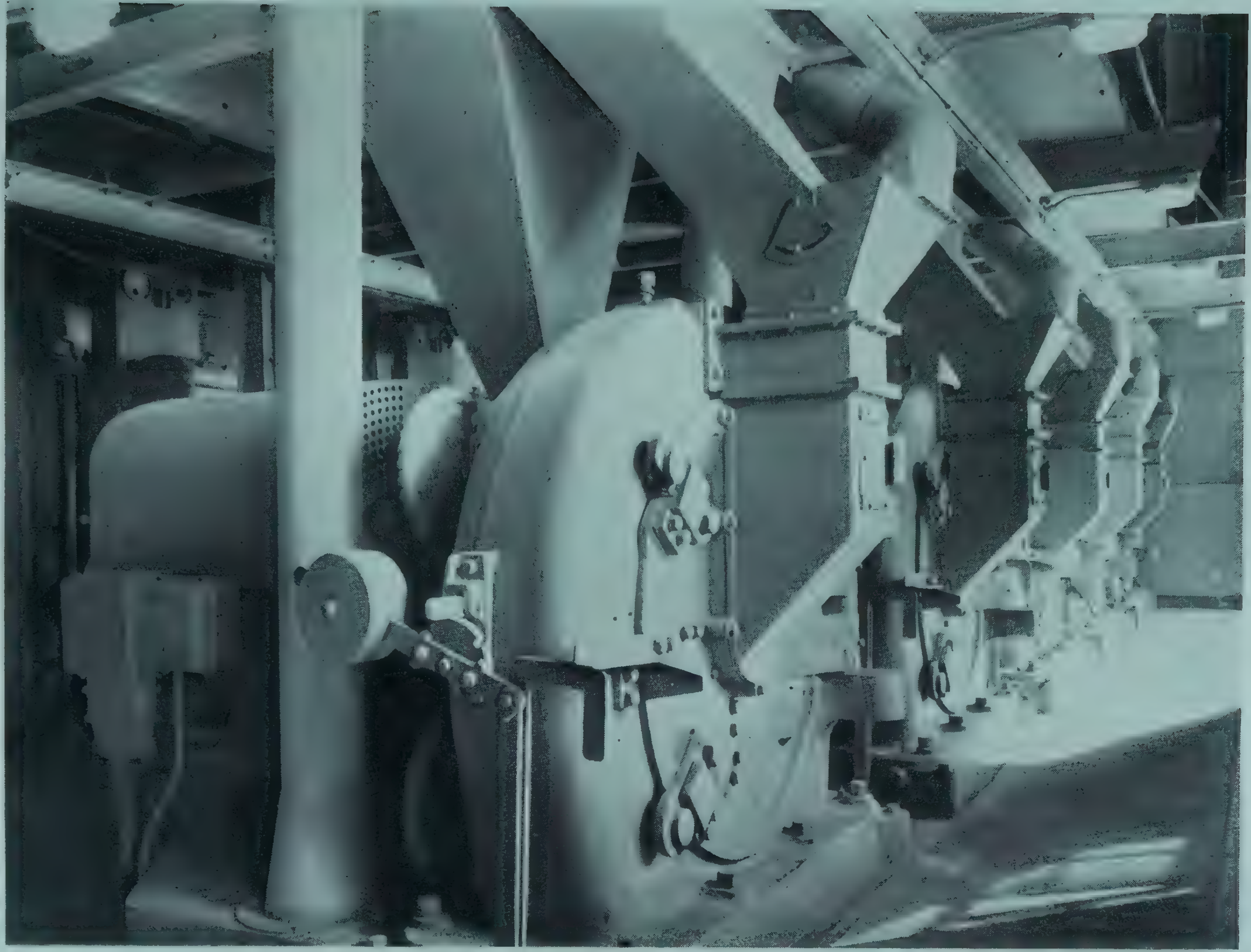


FIG. 97.—A line of Perplex grinders in a modern compound mill.

operation, alternative runs are provided so that the slabs may pass to a pulveriser either through a cake breaker or direct; the former, although slower, gives a controlled feed and prevents sudden power stresses on the pulveriser motor. The ground product passes to a high capacity sieve fitted with 16 mesh, the overtails going to the second grinding operation which, in this case, is performed by a fixed beater grinder. The ground meal also delivers to a sieve, which can be fitted in the same frame as the first sieve, the troughs in each case being the finished product.

(*b*) HIGH CAPACITY ATTRITION AND PERCUSSION TYPE FOR COARSE GRAINS

Attrition grinders give a coarse grind and are utilised more efficiently when followed by a percussion grinder; the plant (Fig. 99) gives a high capacity per horse-power, particularly when grinding maize, beans, peas and other coarse grains ; it is sometimes used in large mills, the ground meals being used either as straights or in compounds.

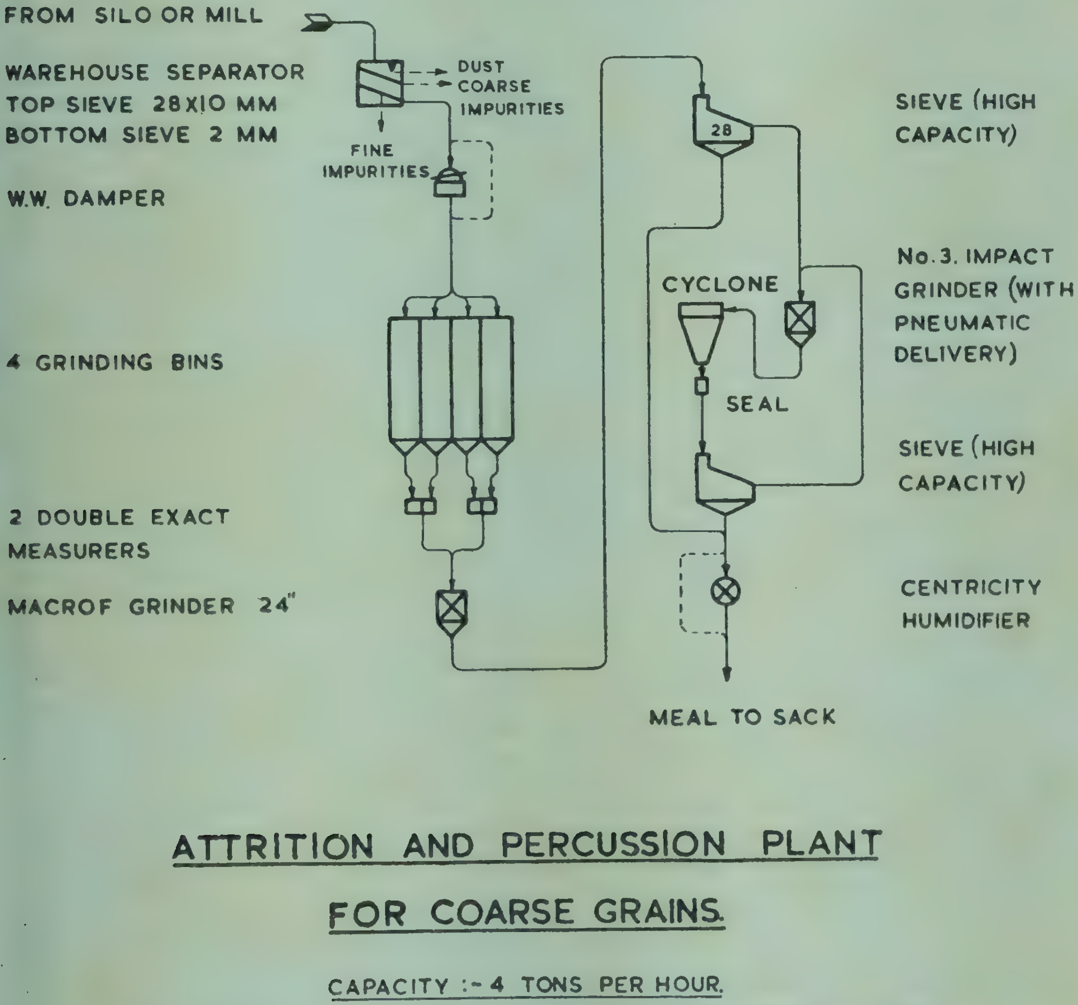
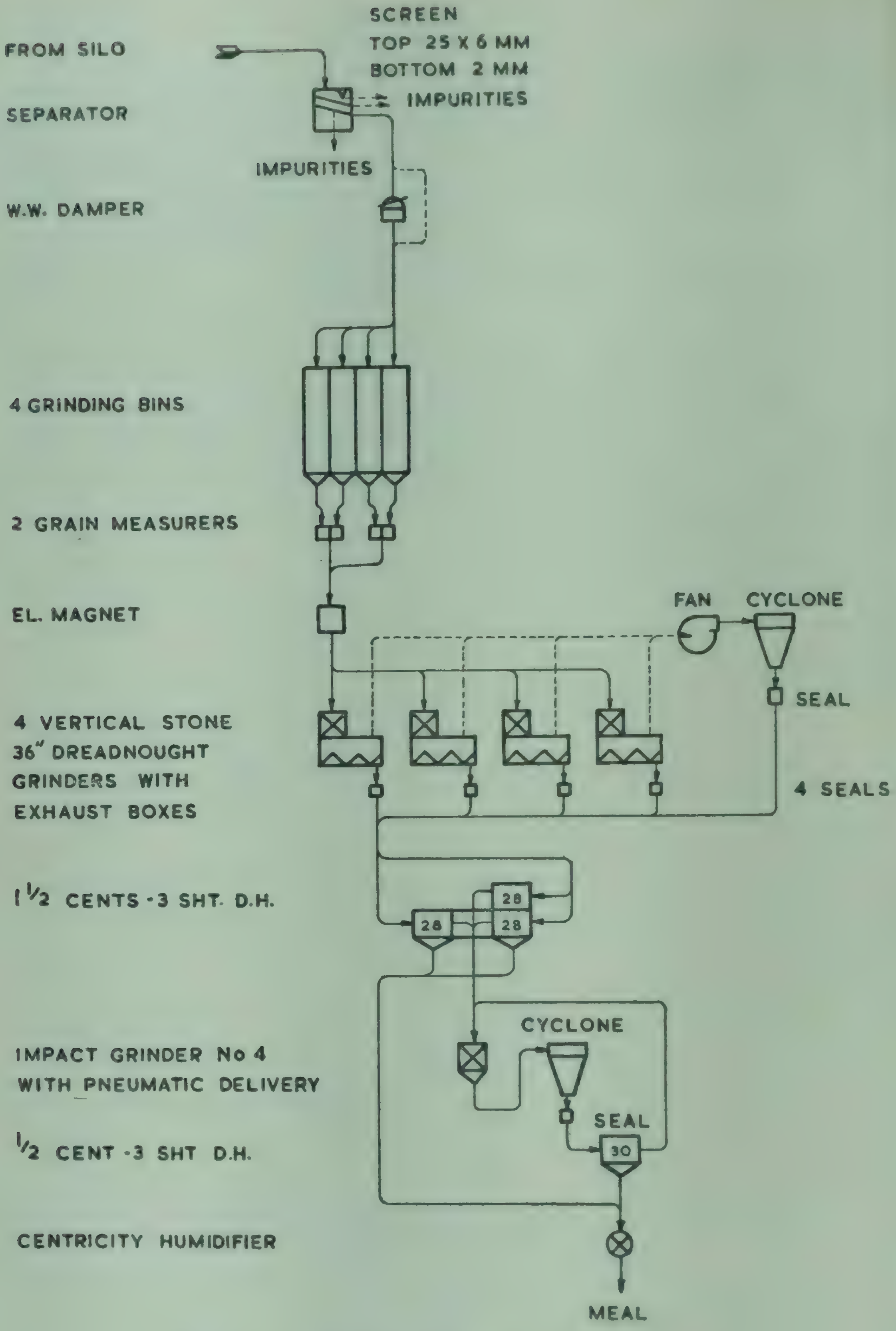

FROM SILO OR MILL
WAREHOUSE SEPARATOR
TOP SIEVE 28X10 MM
BOTTOM SIEVE 2 MM
DUST
COARSE IMPURITIES
FINE IMPURITIES
W.W. DAMPER
4 GRINDING BINS
2 DOUBLE EXACT MEASURERS
MACROF GRINDER 24"
SIEVE (HIGH CAPACITY)
28
CYCLONE
No. 3. IMPACT GRINDER (WITH PNEUMATIC DELIVERY)
SEAL
SIEVE (HIGH CAPACITY)
CENTRICITY HUMIDIFIER
MEAL TO SACK
ATTRITION AND PERCUSSION PLANT
FOR COARSE GRAINS.
CAPACITY :- 4 TONS PER HOUR.

FIG. 99.—High capacity attrition and percussion plant for coarse grains.

Warehouse separators are more often found in a plant of this type, particularly when it is used for grinding straights in provender mills; in the case of maize, top sieves of separators are clothed with 28 × 10 mm. hole-perforated screens which overtail coarse impurities, and bottom sieves


FROM SILO
SCREEN
TOP 25 X 6 MM
BOTTOM 2 MM
SEPARATOR
IMPURITIES
IMPURITIES
W.W. DAMPER
4 GRINDING BINS
2 GRAIN MEASURERS
EL. MAGNET
FAN
CYCLONE
SEAL
4 VERTICAL STONE
36" DREADNOUGHT
GRINDERS WITH
EXHAUST BOXES
4 SEALS
1½ CENTS -3 SHT. D.H.
28
28
28
IMPACT GRINDER No 4
WITH PNEUMATIC DELIVERY
CYCLONE
SEAL
30
½ CENT -3 SHT D.H.
CENTRICITY HUMIDIFIER
MEAL

STONE GRINDING PLANT.

CAPACITY :-1 TON PER HOUR SUSSEX GROUND OATS.

2 TONS PER HOUR BARLEY MEAL

Fig. 100.

2 mm. hole perforated screens for extracting fine impurities. In Fig. 99, the throughs of the attrition grinder pass to one half of a double feed centrifugal, the tails going to the percussion grinder and thence to the other half of the centrifugal, the tails returning to the percussion grinder.

3. STONE GRINDER PLANTS

This type of plant is designed for the manufacture of high quality straights, particularly Sussex Ground Oats and Barley meal, for which it is most suitable. As explained in the preceding chapter, however, although stones produce a fine soft meal, their low capacity per horse-power and lack of flexibility limit their use, and this type ot plant has been largely superseded in modern provender mills by the high speed percussion grinder even for straights, and it is, of course, unsuitable for compounds.

On the other hand, it is still thought by some millers that, owing to the present high cost of Sussex Ground Oats and Barley meal, consumers will call for high quality stone ground meals.

In the plant (Fig. 100) which has a capacity of approximately 1 ton per hour of Sussex Ground Oats and 2 tons per hour of Barley meal, the grain is rough cleaned by a warehouse separator; for oats and barley, the top sieve is usually clothed with a 25 × 6 mm. hole-perforated screen, which overtails coarse impurities, and the bottom sieve a 2 mm. hole-perforated screen for extracting fine impurities. The grain may then be damped as explained in Chapter VIII because there are no percussion grinder screens to block up. Alternatively, moisture may be added after grinding.

The addition of a coarsely-fluted cracking roll before the stones will increase the capacity of the plant by opening the grain, but it is not used as a general rule because of over-elaboration. The ground meal from the stones is dressed out through double feed centrifugals, the overtails consisting mainly of husk being more efficiently ground by a percussion grinder. The ground husk also passes to a centrifugal, the overtails returning to the grinder until they are sufficiently reduced to join the main stream of ground meal from the other centrifugals.

4. ROLLER MILL PLANTS

For the reasons explained in the preceding chapter, roller mills are only used occasionally in provender mills, and then only for grinding grain, apart from miscellaneous purposes, such as maize cutting, kibbling and oat rolling (see Chapter XVIII). When roller mill grinding plants are used, they are almost always confined to straights, and, apart from a few exceptions, mainly in Ireland, where high quality maize meal is sometimes used for human consumption, are simplified as much as possible usually only employing two reductions compared with five in flour milling. Dressing is done by centrifugals, plansifters being almost unknown in the industry.

In the plant (Fig. 101) there are two reductions, the first being performed by coarsely fluted rolls having five flutes to the inch on the top roll and seven on the bottom, and the second by rolls carrying sixteen flutes to the inch on both rolls. In each case, the ground meal is dressed out by one half of a double-feed centrifugal clothed with a 24 mesh wire cover, the tails of the first half going to the second reduction and those of the second half, which are mainly husk, going to a percussion grinder. A half sheet, clothed with a No. 8 mesh known as a ' cut off ', may be arranged to enable maize grits for poultry to be manufactured at the same time as maize meal. The meal may be used as straights and it is, of course, of better quality than that produced by percussion grinders in one operation. As an alternative, the meal may be used in compounds but then coarser covers should be fitted on the centrifugals.

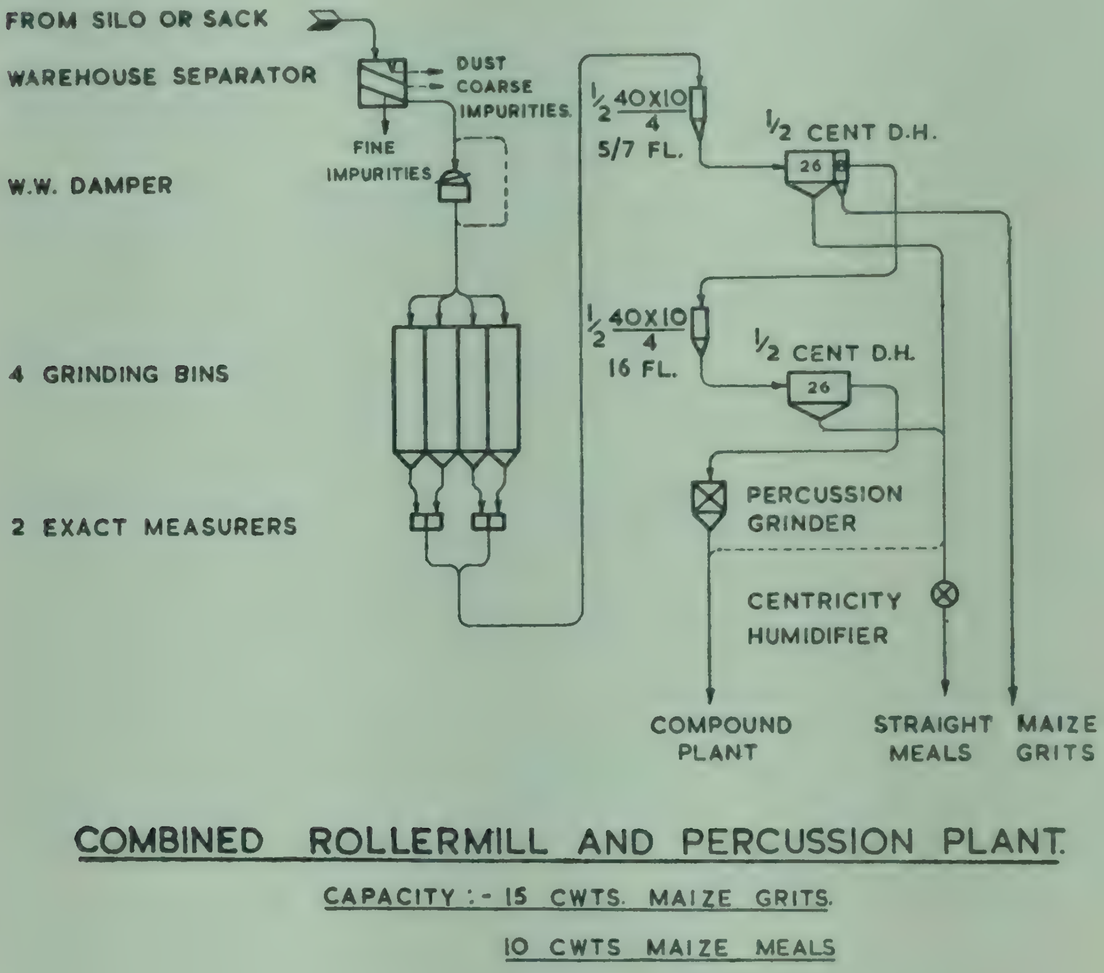
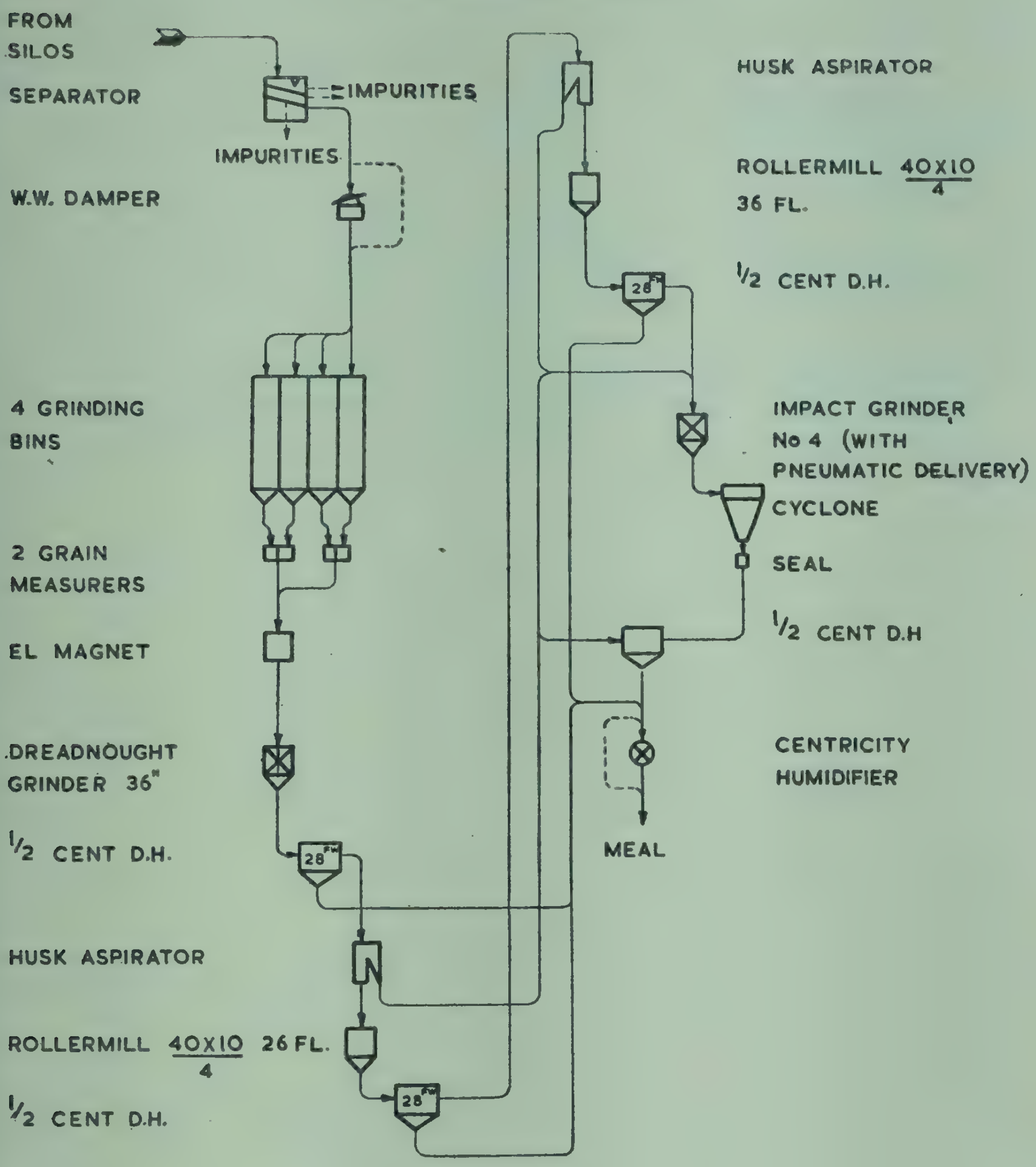

FROM SILO OR SACK
WAREHOUSE SEPARATOR
DUST
COARSE
IMPURITIES
FINE
IMPURITIES
W.W. DAMPER
4 GRINDING BINS
2 EXACT MEASURERS
½ 40X10 / 4
5/7 FL.
½ CENT D.H.
26
½ 40X10 / 4
16 FL.
½ CENT D.H.
26
PERCUSSION
GRINDER
CENTRICITY
HUMIDIFIER
COMPOUND
PLANT
STRAIGHT
MEALS
MAIZE
GRITS
COMBINED ROLLERMILL AND PERCUSSION PLANT
CAPACITY :- 15 CWTS. MAIZE GRITS.
10 CWTS MAIZE MEALS

Fig. 101.

5. COMBINED STONE, ROLLER MILL AND PERCUSSION PLANTS

Occasionally, grinding plants of a more elaborate nature are used for high quality straights or for specific purposes. They may include most of the various types of grinders, the grinders being arranged so that the chief features of each are employed to the best advantage. A typical diagram of a plant is illustrated in Fig. 102.

Stone grinders may be used for light grinding to break open the grain and loosen the husk from the endosperm, thereby reducing their high power consumption and increasing their capacity. The husk, after being separated by centrifugals and husk aspirators, is then ground on percussion grinders, which are more suitable for this purpose than either stones or roller mills. On the other hand, the higher power consumption of percussion grinders is


FROM SILOS
SEPARATOR
IMPURITIES
IMPURITIES
W.W. DAMPER
4 GRINDING BINS
2 GRAIN MEASURERS
EL MAGNET
DREADNOUGHT GRINDER 36"
½ CENT D.H.
28"
HUSK ASPIRATOR
ROLLERMILL 40X10/4 26 FL.
½ CENT D.H.
28"
HUSK ASPIRATOR
ROLLERMILL 40X10/4 36 FL.
½ CENT D.H.
28"
IMPACT GRINDER No 4 (WITH PNEUMATIC DELIVERY)
CYCLONE
SEAL
½ CENT D.H
CENTRICITY HUMIDIFIER
MEAL

COMBINED STONE ROLLERMILL AND PERCUSSION PLANT. FOR HIGH QUALITY STRAIGHTS.

CAPACITY :- 1 TON PER HOUR.

FIG. 102.

not employed on processing that can be more economically done by other machines.

The major part of the grain, namely the endosperm, is then ground by roller mills which give a finer, cooler grind and consume less power in proportion to their output than stones and percussion grinders. A combined plant, therefore, gives a good quality meal with a minimum evaporation loss and power consumption; it also has the advantage of flexibility for various types of grain, but its elaborate nature limits its use in provender milling to the manufacture of only the highest quality straights in one or two large mills.

It will be noticed that in Fig. 102 the centrifugals on each reduction dress out the ground meal, and husk aspirators are introduced to separate the husk from the endosperm. This gives a better separation of the light husk, which is sent direct to the percussion grinder at the tail of the plant and ensures a clean sample of endosperm going to the roller mills. Air or husk aspirators enable the roller mills to produce a meal of brighter and more even texture because roller mills are not suitable for husk grinding except when the flutes are very sharp or when special ‘ Collins ’ flutes are used.

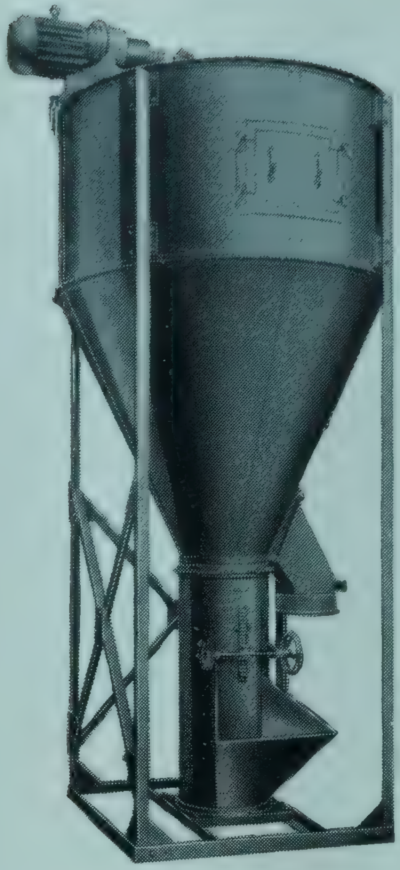


Fig. 103.—The side-hopper-fed vertical mixer for a single storey building.

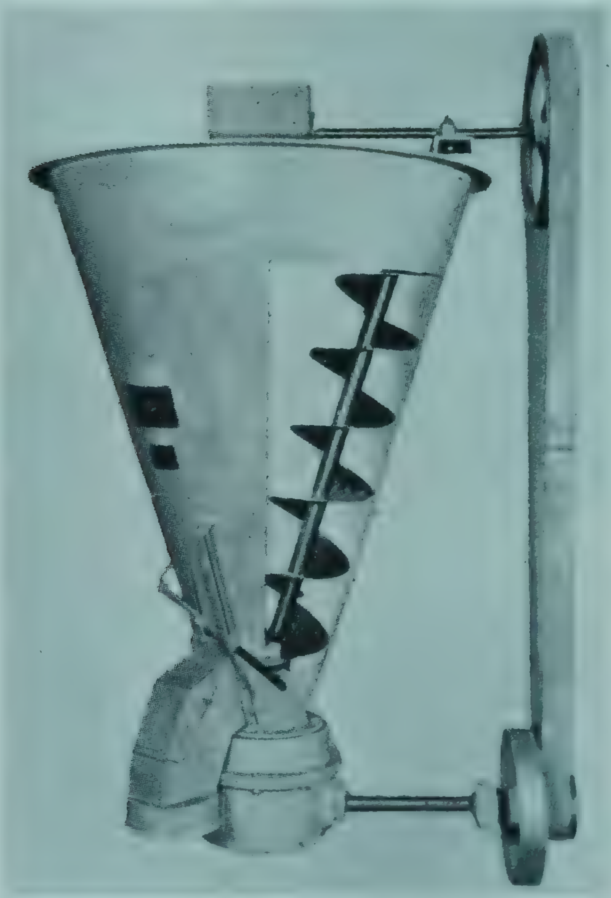


Fig. 104.—The Nauta counter-current mixer.

Chapter XI

MIXERS

MIXERS may be placed in three categories:

(1) Vertical batch mixers.
(2) Horizontal batch mixers.
(3) Continuous mixers.

(1) VERTICAL BATCH MIXERS

Vertical batch mixers as a class most nearly meet the requirements of the compound miller for dry materials; they are cheaper and take less power than other types and, if provided with quick feeding and delivery facilities, are capable of mixing a batch of ingredients in 15-20 minutes sufficiently well for most compound purposes; they are not suitable for mixing molasses with dry materials because molasses will foul the mixer sides and worm. The relatively small quantities of cod liver oil used in compounds may, however, be mixed quite satisfactorily.

Vertical mixers are made by a number of manufacturers and are mostly of similar design; the Fountain Mixer, made by W. S. Barron & Son Ltd. (Fig. 105), is a typical example. The design consists of a cylindrical chamber and hoppered bottom, with a central spiral worm running at approximately 40 r.p.m., driven through bevel reduction gears from a lineshaft or geared motor.

The separate ingredients are fed by hand or from a bin into the chamber and are continuously lifted by the worm to the top of the mixer, whence they fall outwards and downwards to the bottom again. When the mixer is full, a mixing time is allowed and the batch is then discharged either by means of an outlet slide at the bottom of the hopper or at the side. The total mixing time of 15-20 minutes per batch includes filling and emptying, the exact time depending on the nature of the ingredients, the size of the mixer and the method of feeding and delivery.

The main advantages of side delivery spouts are that they allow a much greater rate of discharge, as the area of the spout is unlimited, and they lend themselves to mechanised or remote control. Also they are useful when directly feeding an elevator because this saves height in the layout of the plant. If alternative runs are required, delivery spouts may be fitted on all four sides of the machine.

The most efficient mixers of this type incorporate stirring arms at the bottom of the worm and/or a worm tapered towards the outlet instead of being parallel all the way down. This assists the discharge of the material and minimises the possibility of any unmixed material clinging to the sides of the mixer. The pitch of the worm blades should be gradual enough to give a good throw to the material and keep it circulating, thereby minimising the tunnelling action of the worm through the stock, which is a tendency in all vertical mixers of this type when working on meals.

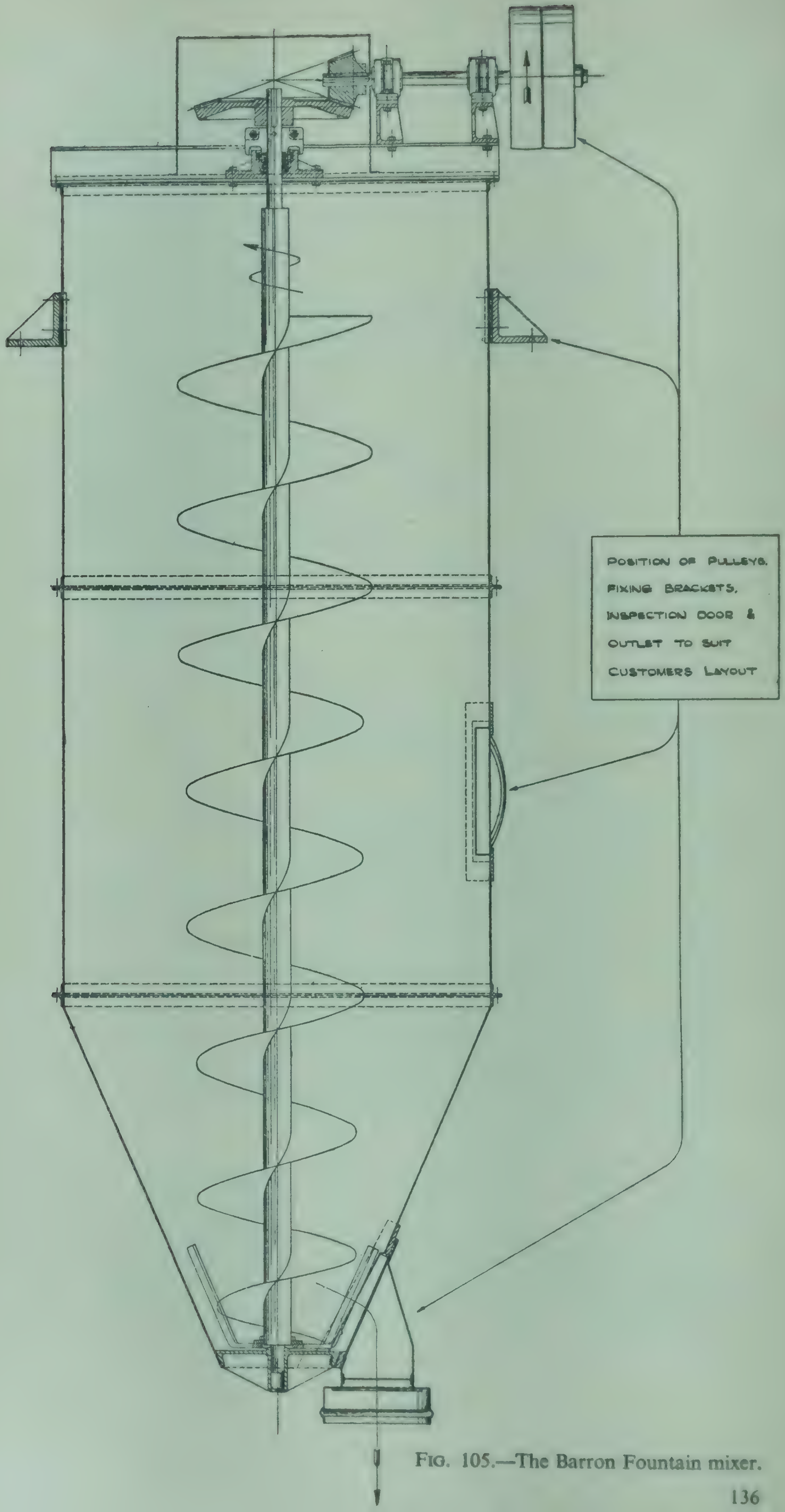

POSITION OF PULLEYS.
FIXING BRACKETS,
INSPECTION DOOR &
OUTLET TO SUIT
CUSTOMERS LAYOUT

FIG. 105.—The Barron Fountain mixer.

THE SIDE-HOPPER FED VERTICAL MIXER

Some manufacturers also make a similar type of mixer with a side hopper feed. Fig. 103 shows the Barron machine. It has the advantage that it may be fed by means of a side hopper on ground-floor level, thereby eliminating the work of elevating the ingredients either in bags or in bulk as is necessary with the foregoing type, and at the same time enabling the mixed compound to be packed off on the same floor. Its use is limited because in the majority of mills, which are of three, four or more storeys, the layout makes it necessary to elevate to the top storey.

However, it is suitable for millers and corn merchants operating on a relatively small scale and who wish to manufacture compound meals in a single storey building. The expense of an elevator is saved, as well as the complication of driving it, and the height of building required for an elevator to feed the machine is avoided. This machine is also useful in self-contained plants, as, for example, grass cubing plants installed in one frame in single storey buildings.

The Vertical 'Spray' Type Mixer

This machine (Fig. 106) is manufactured by Henry Simon Ltd. In outward appearance and general arrangement it is similar to the fountain or geyser mixer but the vertical worm is enclosed by a cylinder, having staggered apertures throughout its height and two conical shrouds at its base. A ring plate is fixed to the top of the worm cylinder, and is swept by vanes which are attached to the worm shaft. A rotor arm fitted with fins also rotates with the worm at the bottom of the mixer.

The ingredients, which are fed in at the top, pass first through the concentric spaces formed by the conical shrouds and the hopper, where they receive a certain amount of premixing before being gathered by the worm. The worm then elevates the premixture in the cylinder, a proportion being discharged through the apertures at various heights, and a proportion on to the ring plate from which it is swept off in the form of a spray by the vanes. The rotor arm at the bottom of the mixer facilitates the discharge of the mixed material.

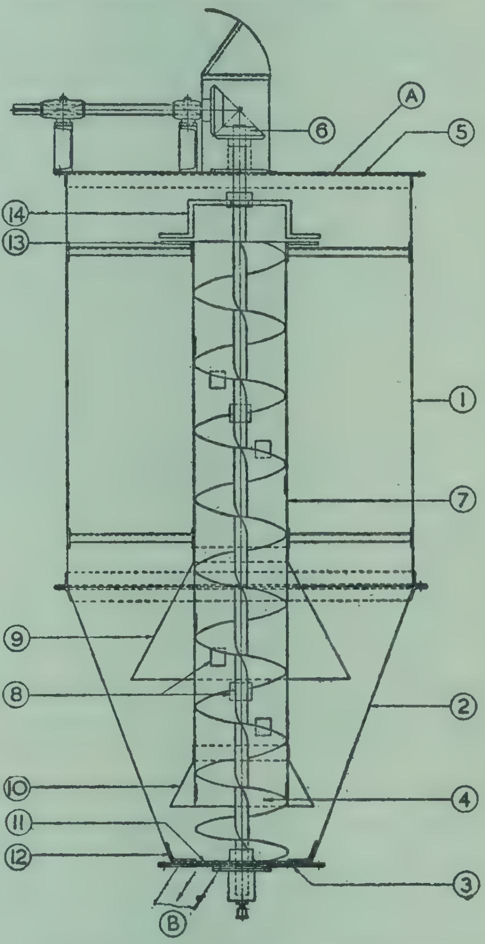


FIG. 106.—The Simon vertical spray mixer.

1. Mixing chamber. 2. Tapered hopper. 3. Base plate. 4. Vertical worm. 5. Top plate. 6. Drive. 7. Enclosed cylinder. 8. Apertures. 9. Conical shroud. 10. Conical shroud. 11. Rotor arm. 12. Fins. 13. Ring Plate. 14. Vanes. A. Feed inlet. B. Discharge.

It will thus be seen that a combination of mixing operations takes place simultaneously whereby mixing time per batch is saved; more batches can be passed through the mixer per hour thus increasing the capacity of the machine and reducing the horse-power per ton as compared with the geyser type mixer. In addition the enclosure of the worm prevents the tunnelling action of the geyser type.

THE 'NAUTA' COUNTER CURRENT MIXER

This machine (Fig. 104) is made by J. E. Nauta of Haarlem, Holland, and is designed on a novel principle in which the worm revolves round the side walls of the conical mixing chamber. The worm itself is rotated by a worm gear drive at the bottom of the machine, the circular motion round the mixer walls being arranged by a bevel gear drive connected by an arm inside the mixing chamber to the top of the worm. The makers claim that the resulting counter-current movement imparted to the material in a vertical and horizontal direction gives an efficient and intimate mixing. This more elaborate design makes the machine suitable for mixing chemicals, but it is also used on the continent for compound feeding stuffs.

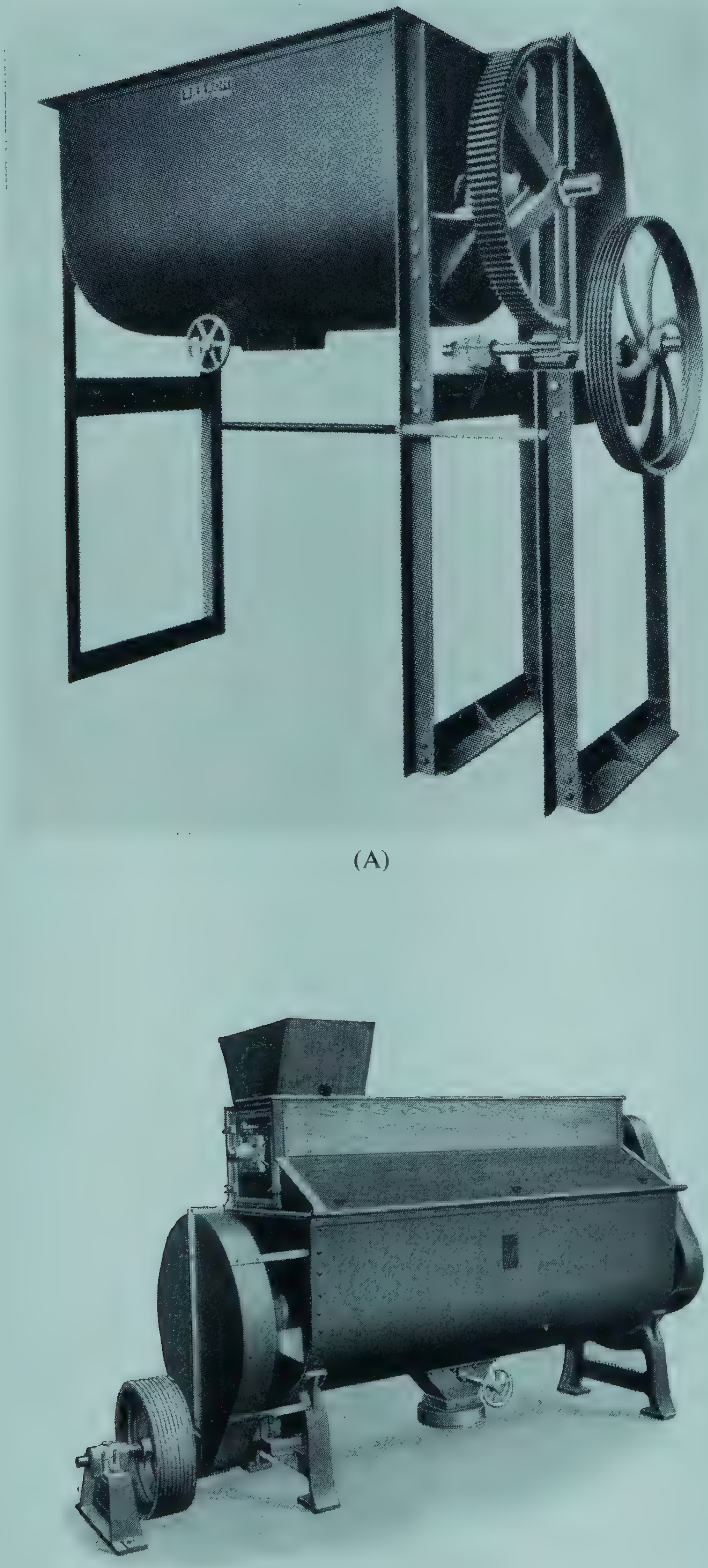
(2) HORIZONTAL BATCH MIXERS

Horizontal mixers give a better and more intimate mix than the vertical type and the majority are capable of mixing molasses or other liquids with dry materials as well as the dry materials themselves; they are suitable for mixing materials of varying density and particle size as, for example, meals, flaked maize, and kibbled oilcakes, which constitute a coarse dairy ration that is popular in some districts; they are more usually found in mills where a large proportion of compound meals and molassed meals are manufactured; but in cubing and pelleting plants their advantage of being able to mix molasses is offset by the fact that. in this country, cubing machines are almost always equipped with their own molasses mixers. Further, when it is noted that horizontal mixers are mostly about three times more expensive than the vertical type and consume about 4-5 times more power, particularly when mixing molasses, it will be seen that their use in compound mills is limited. In cubing and pelleting plants, the vertical mixer is usually all that is required.

THE BARRON HORIZONTAL MIXER

This machine (Figs. 107A and B) may be supplied with or without a brush sifter. It is, however, general practice to place the brush sifter at the head of the plant, although, in some cases, it may be installed after a vertical mixer for convenience in layout (see Mixing Plants). When a sifter, as described on page 79, is fitted to the horizontal mixer, a valve regulates the flow of material into the mixing chamber.

A set of agitators (Fig. 108) arranged in the mixing chamber continually turns the contents over and throws them backwards and forwards. The main mixing shaft runs at 40 r.p.m. and is driven by a set of spur reduction gears, either through a countershaft with fast and loose pulleys or by a vee rope drive from a motor. The brush sifter is driven at about 120 r.p.m. by means of a chain from the mixer shaft. This machine may rest on the floor or it



(A)

(B)

FIGS. 107 (A) and (B).—The Barron horizontal mixer.

may be supported on stands so that the mixed materials may be bagged off underneath on the same floor. When molasses is mixed with the dry materials, gears of a heavier type should be fitted.

THE 'RAPID' SIFTER AND MIXER

This machine is made by Wm. Gardner & Sons Ltd. A special feature is the design of the patented reversible agitating arms which ensure vigorous agitation of the ingredients during mixing. The mixing chamber is provided with a door so that materials which do not require sifting may be introduced direct. In addition, the lower half of the mixing chamber is hinged and can be dropped for cleaning purposes.

THE HOWES HORIZONTAL MIXER

Another type is manufactured by S. Howes (Eureka) Ltd. Four mixing blades mounted on a horizontal shaft, the blades taking the form of steel strips wound round the shaft in a continuous spiral, revolve at 30 r.p.m. in a U-shaped chamber. Two of these spirals fit inside the other two, which has the effect of conveying the ingredients backwards and forwards until they are thoroughly mixed.

THE 'GLOBULAR' MIXER

This machine is made by Richard Sizer Ltd. for mixing meals and molasses but, together with the Barron machine of this type, it has been almost entirely superseded by the more modern method of spraying molasses and by other types of continuous mixers described in this chapter. A heating tank, fitted with a steam coil, warms the molasses to ensure its easy flow, and a small graduated measuring tank enables the correct proportion of molasses to be added to the batch. The mixer itself consists of a heavy cast-iron pan containing six sets of stirring arms mounted on a horizontal shaft which throw the meal inwards and outwards. While the mixing of the dry ingredients is in progress, the molasses is fed from the measuring tank through a perforated steam-actuated pipe to a tray at the top of the mixing pan. The tray is also perforated with small holes which distribute the molasses throughout the mixer. Mixing takes approximately 15 minutes, the batch being finally discharged from the bottom of the pan through a slide operated by a lever. The machine is driven through a pair of gears by means of a countershaft with fast and loose pulleys.

When mixing molasses, most horizontal mixers of 1 ton per hour capacity consume approximately 40 h.p. depending on the percentage of molasses, but when mixing dry ingredients only about 20-30 h.p. is taken. It is by reason of this high power consumption that continuous mixers are now preferred for mixing molasses.

(3) CONTINUOUS MIXERS

Continuous mixers are mainly employed for adding and mixing liquids, such as molasses, cod liver oil, water or steam, with the dry ingredients of the compounds; in batch plants, they also assist the batch mixers to some extent by giving a final mixing to the dry ingredients, and, incidentally, this is another reason why vertical batch mixers are used in preference to the more accurate horizontal type. In continuous plants, where no batch mixers are used and the dry ingredients are blended by volumetric feeders, more work falls on the continuous mixers. It should be noted that in all cases continuous mixers mix dry ingredients only when the ingredients have been blended and enter the machine together.

Some continuous mixers may be installed either as separate units, or as part of the cubing and pelleting machine. There are five types :

(1) The Steam-Jacketed Kettle.
(2) The Cascade Mixer.
(3) The Duplex Mixer.
(4) The Tattersall Mixer.
(5) The Entoleter.

(1) THE STEAM-JACKETED KETTLE

Kettles perform the same work as continuous mixers as regards mixing molasses with meals; they may be installed as separate units or as part of the cubing machine as, for example, in the machines made by Richard Sizer Ltd. and George Porteus & Son (Leeds) Ltd. Several variations and sizes of machines are manufactured which may have one or more compartments.

An example having two compartments, each of which is steam jacketed on the bottom and sides and contains stirrers which mix the molasses with the meal, is illustrated in Fig. 109. Molasses and live steam enter the machine through perforated pipes, the steam pipes being arranged either externally or internally. Some types of kettle are jacketed only on the bottom and not on the sides but most have independent live steam control which give flexibility of adjustment for obtaining the correct condition of meal for the cubing and pelleting process.

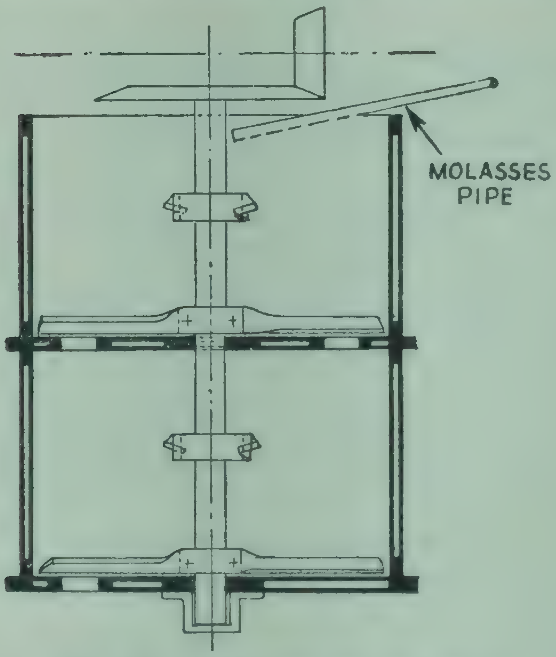


FIG. 109.—The steam-jacketed kettle.

(2) THE CASCADE MIXER

This machine is manufactured by Henry Simon Ltd. and may be supplied either as a separate unit (Fig. 110) or as part of the Californian Press range of cubing machines. In the latter case the layout varies according to the machine. A smaller unit is fitted to the Master Model Press.

The separate unit consists of a shaft with a series of worm blades or lifters enclosed in a combined trough and expansion chamber of deep U section. The blades, running at a moderately high speed, ‘ cascade ’ the meal into the expansion chamber and at the same time throw it backwards

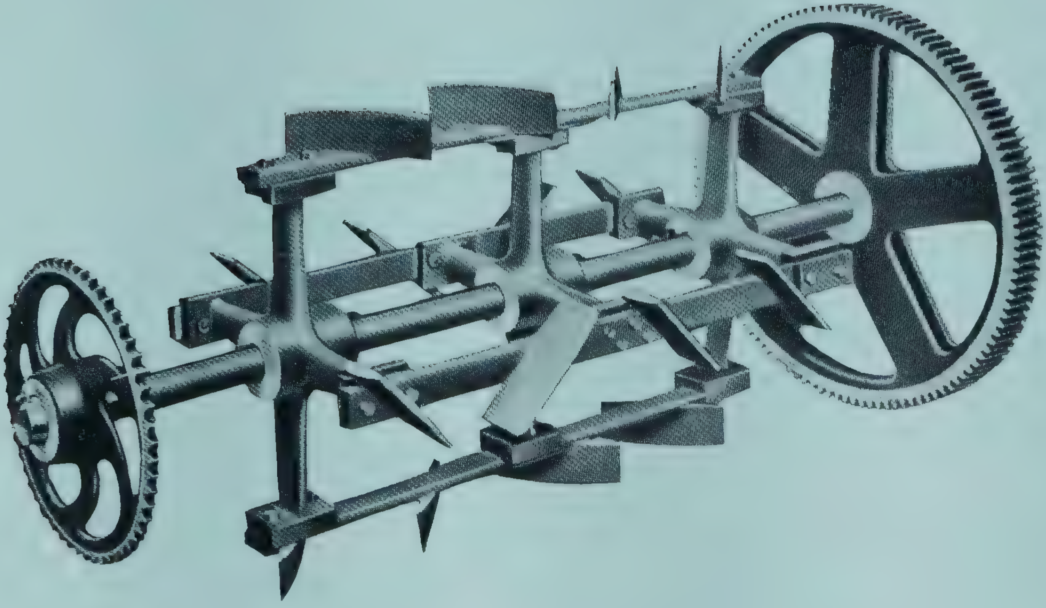


FIG. 108.—The mixing blades of Barron horizontal mixer.

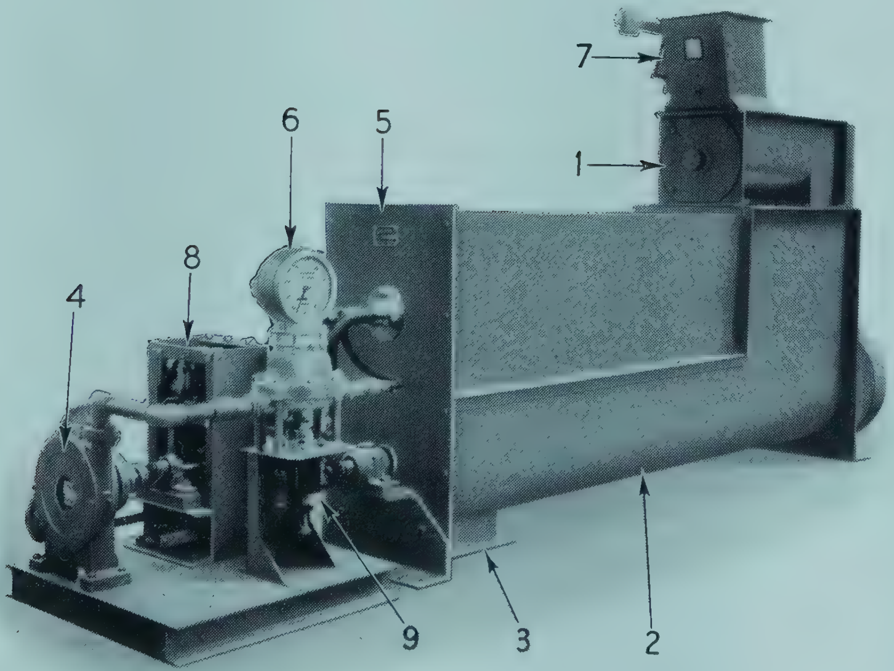


FIG. 110.—The Simon cascade mixer.

1. Feed worm. 2. Mixing chamber containing cascade worm. 3. Meal outlet. 4. Molasses regulator. 5. Molasses and steam atomiser. 6. Molasses meter. 7. Meal spout flow indicator. 8. Stop and start unit. 9. Electro-magnetic steam valve.

and forwards, with a predominating forward movement towards the outlet. Molasses is sprayed into the meal in the form of a fine mist by a steam-actuated atomiser, while the meal is in open suspension in the expansion chamber. This intimate action prevents excessive ' balling ' of the molasses with the meal which results in molasses blobs in the cubes. Also, owing to the fact that the meal is continuously cascaded and is in suspension when it is blended with the fine molasses spray, very little power is required to turn the worm blades as compared with horizontal batch mixers and kettles in which the whole mass of meal and molasses is turned over by stirrer arms.

The meal feed to the cascade mixer passes through a ratchet feed worm which delivers the meal into the end of the machine opposite to the atomiser. The rate of feed can be regulated from approximately 5 tons per hour downwards by varying the stroke of a ratchet and pawl gear, which is mounted on the worm spindle.

The Molasses Assembly Units (Fig. 110)

These are attached to the cascade mixer; they measure, control and record the quantity of molasses flowing to the machine.

The Strainers

The warmed molasses flows by gravity from a steam-heated tank in the top of the mill to two strainers which remove any impurities which might block the atomiser. Each strainer consists of two concentric, perforated, metal cylinders through which the molasses filters. They are designed to give a large filtering area and are easily cleaned by opening the top and lifting out the cylinders containing the impurities which fail to pass through the perforation. The object of having two units is to enable either to be cleaned whilst the other remains in operation.

The Molasses Regulator

From the strainers the filtered molasses flows to the molasses regulator controlling the quantity of molasses passing to the cascade mixer. The regulator consists of a drum which rotates at a constant speed inside a circular housing. Vanes are fitted to the drum and form a series of radial pockets so that the molasses, which enters at the bottom of the housing, is carried round by the pockets and discharged at the top. The drum is mounted eccentrically in a bushing which can be rotated by an external lever; this moves the drum towards or away from the bottom of the housing, thereby reducing or increasing the volume of the pockets and consequently the quantity of molasses. The vanes slide in grooves in order to allow for this eccentric movement.

The rate of delivery can be varied from a ½ lb. to 30 lb. a minute. The movement of the adjusting lever moves a pointer over a graduated scale which shows the capacity at which the regulator is set. The regulator acts as a seal when the drum is stopped. A steam pipe is fitted to the regulator to reduce the possibility of the molasses sticking, which may occur, especially when starting up from cold.

The Molasses Meter

The regulator pumps the molasses through the meter, which shows the quantity of molasses being used at any time on a calibrated dial. A counter, calibrated in hundreds of pounds, records the total amount which has passed through the meter. The meter consists of a chamber in which a disc is rocked about a ball joint by the flow of molasses. The movement of the disc opens and closes the inlet and outlet ports alternately, allowing a fixed amount of molasses to be discharged at each oscillation. This action drives a train of gears and rotates the needle on the dial. A different calibration is required for cod liver oil.

The Atomiser (Steam and Water Spraying)

The molasses passes from the meter to the atomiser where it is joined by the steam which disperses the molasses into a fine mist and sprays it into the meal. When molassed compound meals are manufactured, compressed air may be used instead of steam, because it obviates the problem of cooling the meal. Compressed air is also used for spraying cod liver oil because steam is liable to be harmful to the vitamin content of the oil. The steam pressure for atomising is 30 lb. per square in. and the air pressure 30 lb. per square in.

Electrical Control Units

The cascade mixer is fitted with automatic control units to prevent the possibility of molasses or steam spraying into the machine while there is no meal passing through. If the meal should suddenly stop, a serious congestion of molasses inside the mixer would occur unless safeguarded. These control units comprise:

The Spout Flow Indicator.
The Electro-Magnetic Steam Valve.
The Stop and Start Unit.

The spout flow indicator is fitted to the inlet of the meal feeder, and is provided with a valve which responds sensitively to the flow of meal through the inlet. The movement of the valve operates a mercury switch, connected to the electro-magnetic steam valve and to the stop and start unit, through which the molasses regulator is driven. If the flow of meal stops, the indicator valve is released; the mercury switch then automatically shuts off the steam to the atomiser by means of the electro-magnetic steam valve, and stops the molasses regulator by disengaging the electro-magnetically operated clutch of the stop and start unit. When the flow of meal is resumed, the indicator valve is depressed, thereby automatically restarting the steam and molasses.

The only motive power required is for the regulator and the cascade mixer, which together consume a total of 3 h.p.

(3) THE DUPLEX MIXER

This continuous mixer (Fig. 111) is made by S. Howes (Eureka) Ltd. The machine consists of two agitators running at approximately 250 r.p.m. and arranged parallel to each other in two shallow steel troughs. The

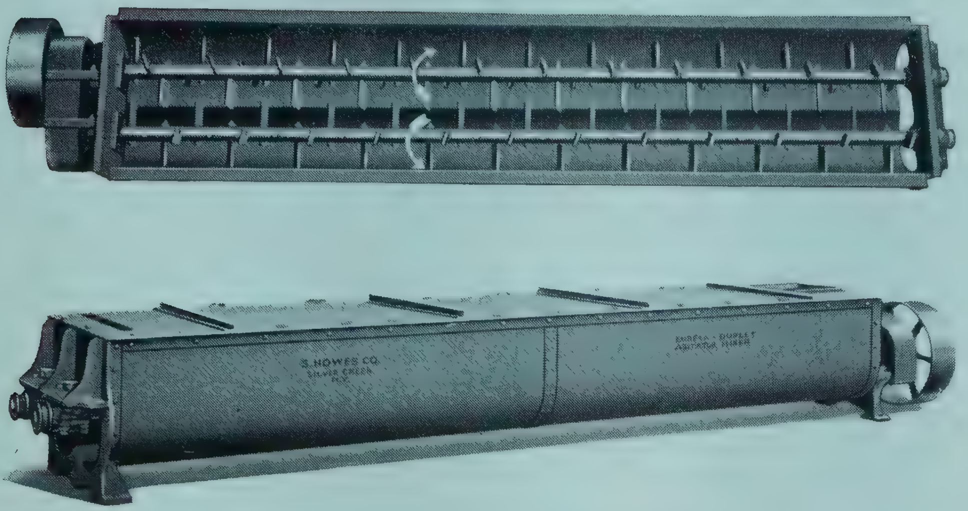

S. HOWES CO.
SILVER CREEK
N.Y.
EUREKA-DUPLEX
AGITATOR MIXER

FIG. 111.—The Howes duplex mixer.

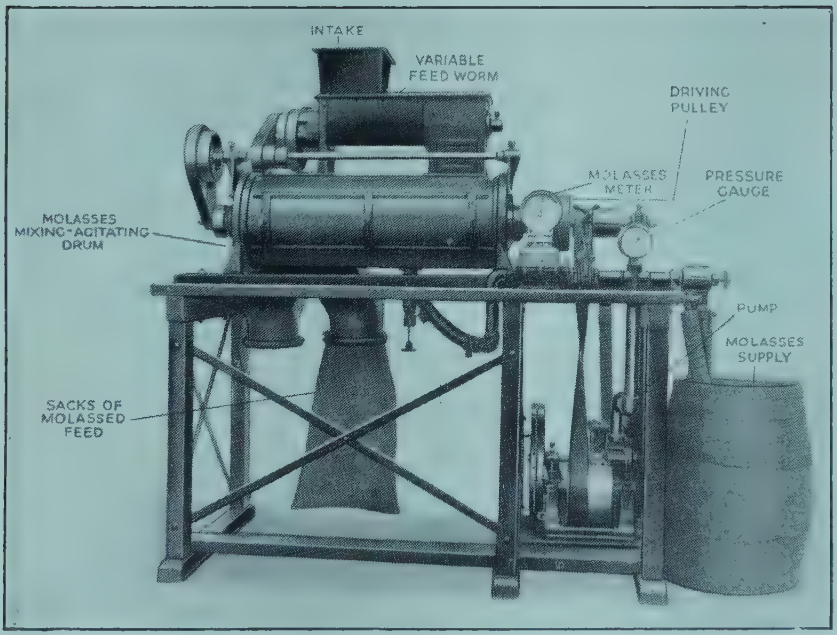

INTAKE
VARIABLE FEED WORM
DRIVING PULLEY
MOLASSES METER
PRESSURE GAUGE
MOLASSES MIXING-AGITATING DRUM
PUMP
MOLASSES SUPPLY
SACKS OF MOLASSED FEED

FIG. 112.—The Tattersall mixer.

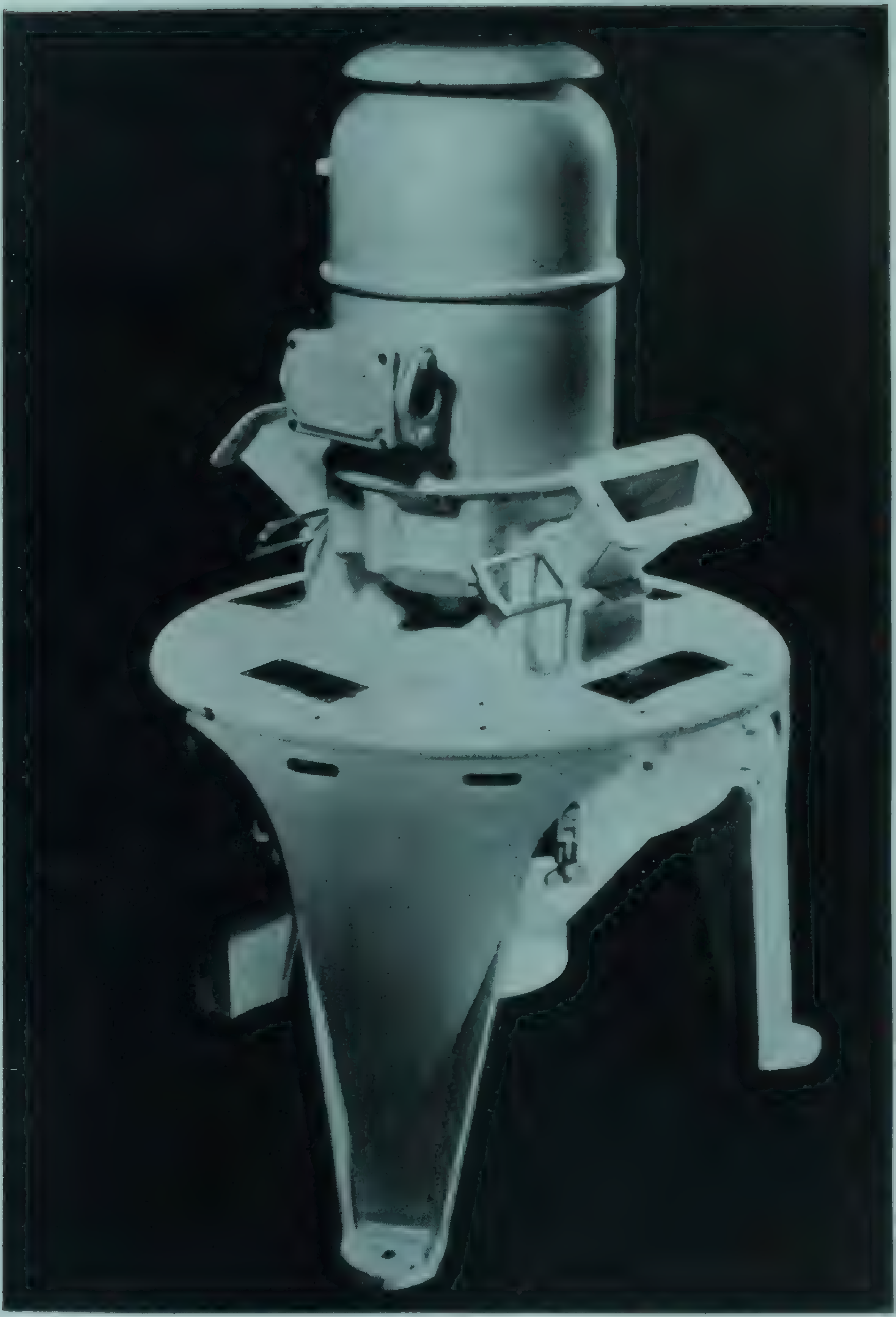


FIG. 113.—Entoleter for intimate continuous blending.

agitators rotate in opposite directions so that the blades move upwards at the centre of the chamber, thereby throwing the contents of each trough towards each other. Adjustment of the mixing action can be made by altering the angle of the blades to the shaft, thus varying the time taken for the ingredients to traverse the length of the mixer. It should be noted that this machine also serves as a conveyor. Molasses may be added to this mixer by an atomiser in the same way as in the cascade mixer, except that the atomiser sprays vertically downwards instead of horizontally.

(4) THE TATTERSALL MIXER

This machine (Fig. 112), made by A. R. Tattersall & Co., is a continuous mixer in which the molasses is mixed into the meal without being heated. It is, therefore, suitable for the manufacture of molassed compound meals because it avoids overheating the meal. The cold molasses is pumped under pressure into a cylinder containing retarding rings and beaters running at about 1000 r.p.m. which break up the molasses and mix it intimately with the meal.

The molasses flow is regulated and measured by a valve, meter and pressure gauge, which can be arranged, together with the pump and variable speed meal feeding worm, as a self-contained unit on a stand as illustrated. Alternatively, the various units can be arranged on separate floors.

(5) THE ENTOLETER

The Entoleter (Fig. 113), distributed by Henry Simon Ltd., is most commonly known amongst food manufacturers as an infestation destroyer, which is its main function. It may, however, also be employed as a continuous mixer and, in compound milling, it has been successfully used for the continuous mixing of dry compound ingredients; for cod liver oil into compound meal; for vitamin and mineral concentrates and for the dispersion of agglomerates which are sometimes formed by the addition of molasses and other liquids to meals. For all these purposes it gives a very intimate mixing.

The working parts of the Entoleter simply consist of a high speed rotor running at 2900 r.p.m. in a closed chamber with a hoppered outlet. The rotor, which is directly driven by a built-in vertical electric motor, consists of two discs with two concentric rings of impactors at its circumference.

The material, which is fed through an inlet spout into the centre of the rotor, is spun out centrifugally between the discs in a thin spray and receives severe percussion against the impactors and walls of the housing. The Entoleter is economical in operation and maintenance, and on installation only requires spouting and connecting to an electrical power supply.

When treating compound meals, Entoleters built with 3, 5 and 7½ h.p. motors cover a capacity range from a few pounds to 4½ tons per hour.

Chapter XII

BLENDING, MIXING AND CUBING PLANTS

THERE are three types :

(1) *Batch plants.*

(2) *Semi-continuous batch plants.*
  - (*a*) Those using portable hand operated weighers for blending.
  - (*b*) Those using fixed hand operated weighers for blending.
  - (*c*) Those using one large weigher for blending.

(3) *Automatic continuous plants.*
  - (*a*) Continuous blending by volume.
  - (*b*) Continuous blending by weight.

BATCH PLANTS

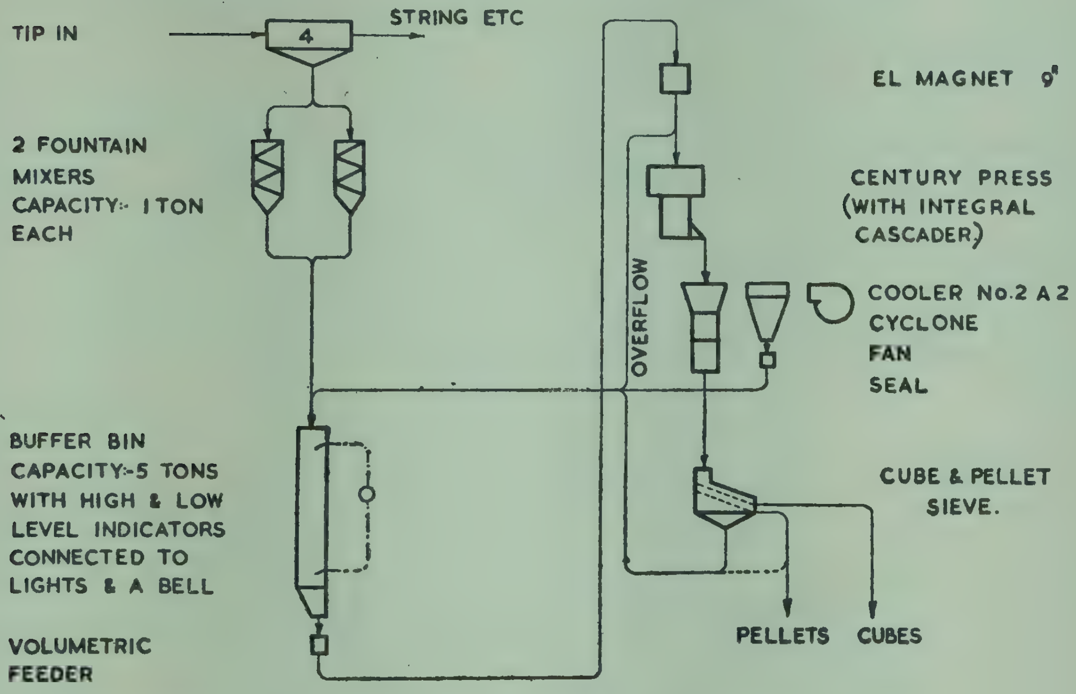
This type of plant is used in the majority of mills and seldom exceeds an output of 10 tons per hour of compounds in meal, cube or pellet form. At this figure it usually becomes uneconomical for the reasons subsequently explained (p. 149); in many country mills the capacity is usually between 2 and 5 tons per hour. Plants (2) and (3) mostly have capacities of 10 tons per hour upwards; they are proportionately fewer in number and are generally found in large port mills.

In batch plants, most raw materials are handled and stored in bags. The exceptions are grain and usually kibbled or expeller cakes, which are bulk handled and stored. Bagged materials are handled by inclined elevators, conveyors and friction hoists, and are stored in a convenient position for feeding into the mixers. Bulk materials are fed into grinding bins from sack, bulk wagon, or silo, ground by percussion grinders, and bagged off for feeding into the mixers as described in Chapters IV and X.

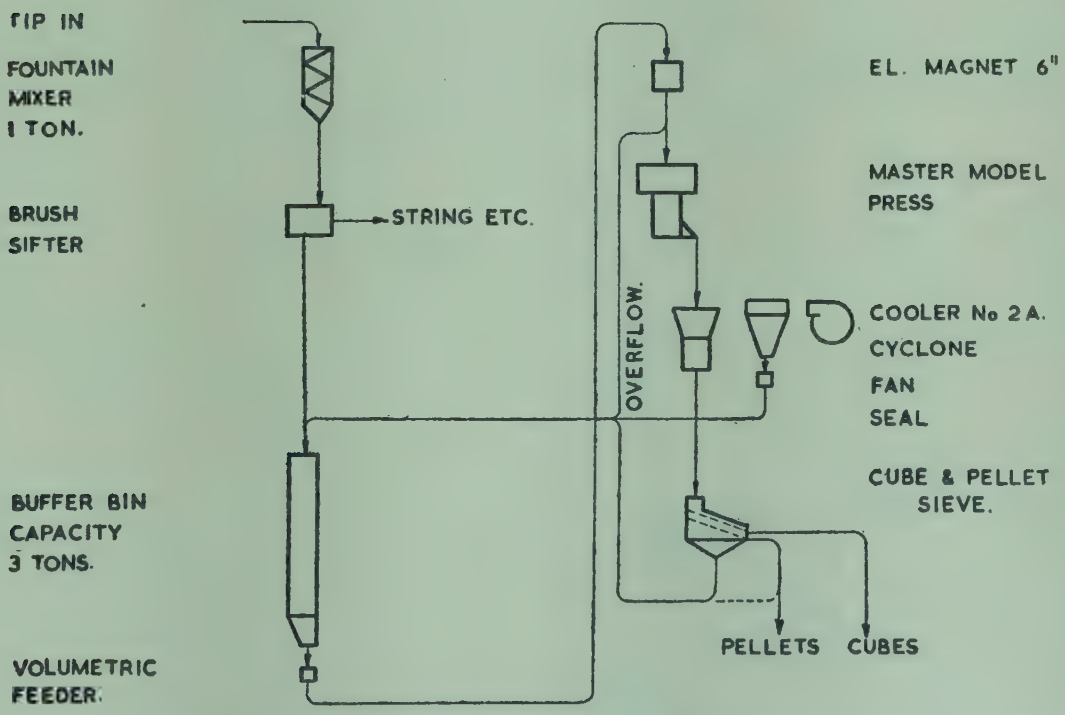
(*a*) DIAGRAMS

Flow diagrams of batch plants are shown in Fig. 114. In the first diagram, a reel clothed with a No. 4 mesh wire, extracts coarse foreign matter before the meal enters the mixers. Two vertical batch mixers are employed working side by side so that one may be filling while the other is mixing and emptying. A buffer bin sufficiently large to take a charge from both mixers with room to spare, is necessary to enable the mixers to be emptied and discharged quickly, thus ensuring a higher hourly mixing output and an uninterrupted feed to the cubing machine.

For smaller capacities as in the second diagram of Fig. 114, only one mixer is necessary. In this case the rough cleaning machine is a brush sifter, which is installed after the mixer. It is usually impracticable to tip bags direct into the cleaning machine because its output has to be high to take the sudden rush of material; also the machine has to be slung under the floor in an inaccessible position to avoid lifting the bags into it. Therefore

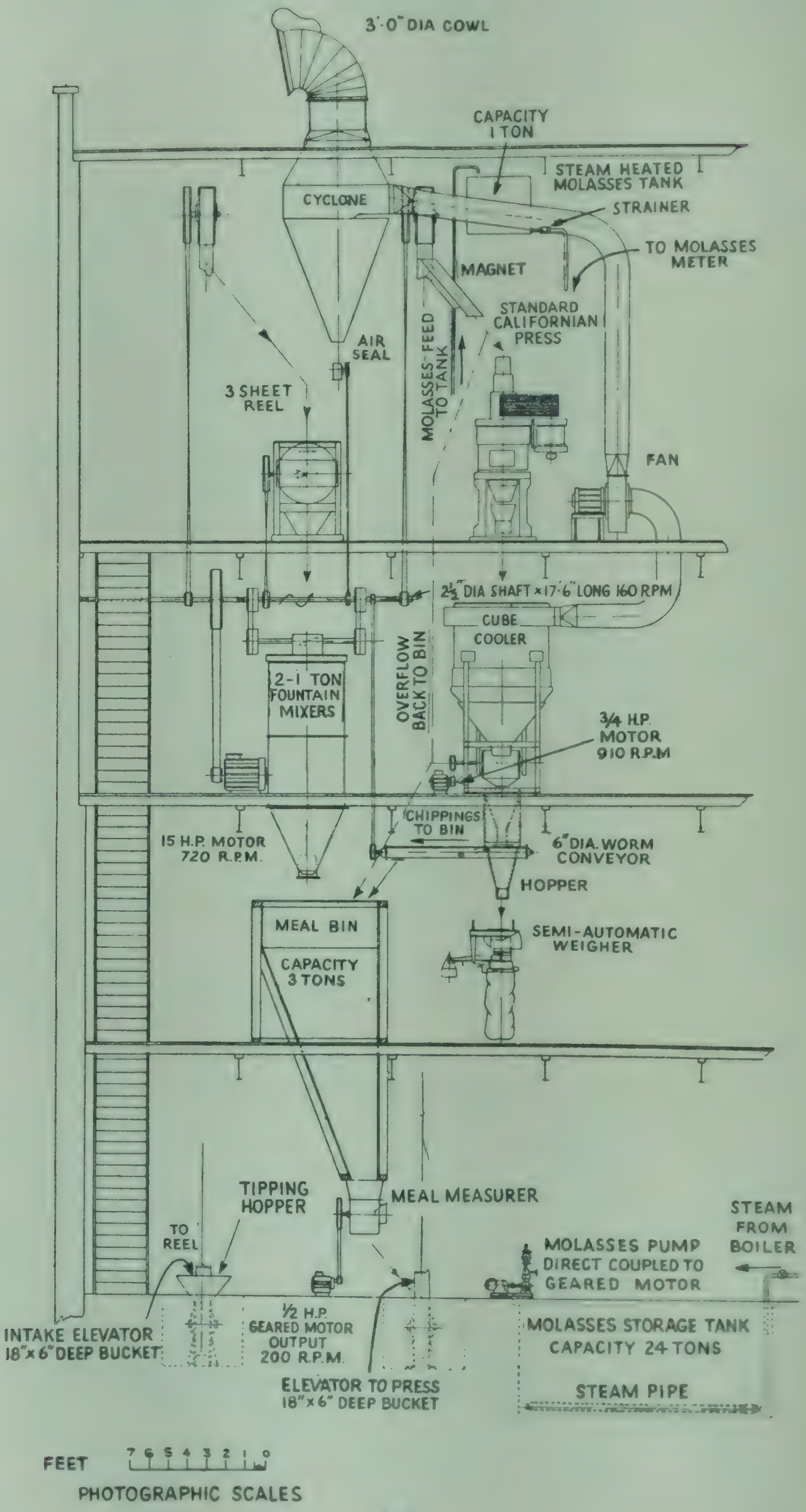

TIP IN
4
STRING ETC
2 FOUNTAIN MIXERS CAPACITY:- 1 TON EACH
BUFFER BIN CAPACITY:-5 TONS WITH HIGH & LOW LEVEL INDICATORS CONNECTED TO LIGHTS & A BELL
VOLUMETRIC FEEDER
EL MAGNET 9"
CENTURY PRESS (WITH INTEGRAL CASCADER)
OVERFLOW
COOLER No.2 A 2
CYCLONE
FAN
SEAL
CUBE & PELLET SIEVE.
PELLETS
CUBES

CAPACITY:- 5 TONS PER HOUR OF $1\frac{1}{2}$" CUBES.
3 " " " " $\frac{3}{16}$" PELLETS.


TIP IN
FOUNTAIN MIXER 1 TON.
BRUSH SIFTER
STRING ETC.
BUFFER BIN CAPACITY 3 TONS.
VOLUMETRIC FEEDER.
EL. MAGNET 6"
MASTER MODEL PRESS
OVERFLOW.
COOLER No 2 A.
CYCLONE
FAN
SEAL
CUBE & PELLET SIEVE.
PELLETS
CUBES

CAPACITY:- 2 TONS PER HOUR OF $1\frac{1}{2}$" CUBES
30 CWTS " " " $\frac{3}{16}$" PELLETS.

FIG. 114.—Batch mixing and cubing plant.


3'·0" DIA COWL
CAPACITY 1 TON
STEAM HEATED MOLASSES TANK
CYCLONE
STRAINER
TO MOLASSES METER
MAGNET
STANDARD CALIFORNIAN PRESS
AIR SEAL
MOLASSES-FEED TO TANK
3 SHEET REEL
FAN
2½" DIA SHAFT × 17'·6" LONG 160 RPM
CUBE COOLER
OVERFLOW BACK TO BIN
2-1 TON FOUNTAIN MIXERS
¾ H.P. MOTOR 910 R.P.M
CHIPPINGS TO BIN
15 H.P. MOTOR 720 R.P.M.
6" DIA. WORM CONVEYOR
HOPPER
MEAL BIN
CAPACITY 3 TONS
SEMI-AUTOMATIC WEIGHER
TIPPING HOPPER
MEAL MEASURER
TO REEL
STEAM FROM BOILER
MOLASSES PUMP DIRECT COUPLED TO GEARED MOTOR
INTAKE ELEVATOR 18"×6" DEEP BUCKET
½ H.P. GEARED MOTOR OUTPUT 200 R.P.M.
MOLASSES STORAGE TANK CAPACITY 24 TONS
STEAM PIPE
ELEVATOR TO PRESS 18"×6" DEEP BUCKET
FEET
7 6 5 4 3 2 1 0
PHOTOGRAPHIC SCALES

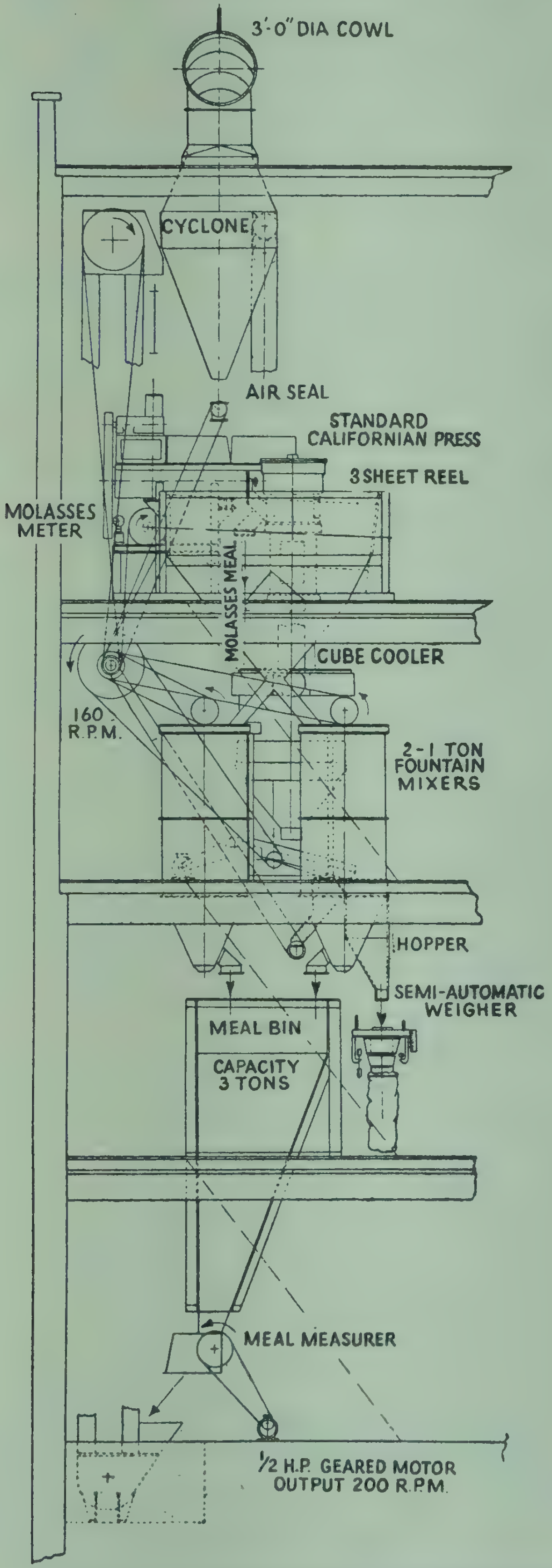

3'-0" DIA COWL
CYCLONE
AIR SEAL
STANDARD CALIFORNIAN PRESS
3 SHEET REEL
MOLASSES METER
MOLASSES MEAL
CUBE COOLER
160 R.P.M.
2-1 TON FOUNTAIN MIXERS
HOPPER
SEMI-AUTOMATIC WEIGHER
MEAL BIN
CAPACITY 3 TONS
MEAL MEASURER
½ H.P. GEARED MOTOR OUTPUT 200 R.P.M.

FIG. 115.—Batch mixing and cubing plant layout.

unless the layout lends itself to feeding the mixers by bulk elevators thereby ensuring a controlled feed as in the first diagram, it is better to empty the bags direct into the mixers, which may be slung from the floor, and to place the cleaning machine after the mixers, in which case its feed is controlled by the mixer outlet slides. Alternatively a fixed grid may be placed over the mixers to extract strings and rubble instead of a cleaning machine, but this is not so efficient.

(*b*) LAYOUT

An ideal layout for a batch plant occupies four floors each having a minimum height of 10 ft. (Fig. 115) or three higher floors. The top floor should be at least 16 ft. high to the eaves to house elevator heads and to give sufficient height to feed to the machines without the need of horizontal conveyors. Single or two storey buildings require more elevators and necessitate the elevating of hot cubes which should always be avoided if possible.

In Fig. 115, which is based on the first diagram (Fig. 114), a bulk elevator delivers to a reel on the top floor and thence to the mixers, thus giving flexibility by enabling the bagged raw materials to be stored and emptied on any floor. Only one floor should be used for feeding materials into the elevator and mixers at the same time or mistakes in the making up of batches may occur. In this layout, ground materials from the grinders are packed off on any floor for feeding into the elevator.

On the other hand, the building may lend itself to the elevating of the bagged materials by inclined elevators and the storage of the bags on the top floors in readiness for tipping direct into the mixers as in the second diagram. In the same way, ground materials may be bulk elevated from the grinders and packed off on the top floor. Small hoppers on the top floor holding a reserve of ground material to be drawn off by the mixer operators as required, are most useful, particularly when situated close to the mixers and fitted with some form of hand operated fixed weigher hopper as described in the semi-continuous system.

Four floor layouts (Fig. 115) enable the cubing machine to be installed on the top or third floor, the cooler underneath on the second floor and the packers on the first floor, which is usually the most convenient height for the loading of finished products; this leaves the ground floor for reserve storage which also may be used for loading out. In three or four storey buildings of reasonable height, no elevating of hot cubes should be necessary. In three floor buildings, when the ground floor is not a convenient height for loading the lorries, the cooled cubes may be bulk elevated to the packers after first passing over a sieve on the top floor which extracts dust and chippings.

Generally 1 or 2 ton batches are the most convenient size for calculation and handling purposes; other sizes should be avoided. Labour is saved if batches are as large as possible in relation to the hourly output of the plant because little extra time is taken to make a large batch than a small one. Also labour and time are saved if the compound formulae are calculated so that full bags of known weight are used instead of odd fractions.

In the second diagram, a mixer may be installed in place of the buffer bin; it is almost as cheap as erecting a bin and the vertical worm in the mixer agitates and assists the discharge of the meal. When a buffer bin is used, a Volumetric Feeder is necessary to discharge and control the mixed meal from the bin into the elevator feeding the cubing machine; when a mixer is used the combination of the worm and outlet slide is sufficient to control the discharge. In the Californian Press range and other cubing machines employing continuous ratchet feeders, which work on a full spout, an overflow spout is necessary to return the excess feed to the buffer bin. This overflow must branch off after the magnet because the latter, which is essential before a cubing machine, will not work efficiently on a full spout.

(*c*) COD LIVER OIL MIXING

In batch plants, an easy and accurate method of mixing cod liver oil is to add it in the batch mixers while they are being filled; this may be done very simply and cheaply either by inverting a 1 or 2 gallon can with a cock through a hole in the top cover of the mixer; or by a 10 gallon graduated tank, two valves and two short lengths of pipe. A more efficient mixing is obtained if the oil is sprayed into the mixers by compressed air through an atomiser. The amount of air required for spraying 1 or 2 per cent of cod liver oil is 12 cu. ft. per minute at a working pressure of 20-30 lb. per square in. Fish solubles may be mixed in the same way. Molasses cannot be mixed satisfactorily in vertical worm type batch mixers.

(*d*) THE USE OF THE BATCH PLANT

As referred to in the first paragraph, the batch plant is the most suitable for all those undertakings having a production capacity of under 10 tons per hour of compounds and with no prospect of exceeding this figure, because it requires the smallest capital outlay and is the simplest to install in the average mill building. However, as the output approaches the 10 ton per hour figure, the labour and space required for handling and storing so many bags increases to such an extent that in most mills the plant becomes both uneconomical and impracticable. It is in these circumstances that further capital outlay is justified for the installation of bins and accessory equipment to hold as large a proportion of the bagged materials as possible, and to make the plant more efficient and labour-saving on semi-continuous or continuous lines.

SEMI-CONTINUOUS BATCH PLANTS

(*a*) DIAGRAMS

In Fig. 116, grain and oilcakes are bulk fed to grinding bins and ground separately in the same way as in the batch plant. After grinding, they are delivered direct, and usually by pneumatic means, to a range of meal process bins ready for blending with the other ingredients. It is at this point that double handling and much of the labour is saved compared with the batch plant in which the ground materials have to be packed off, weighed and conveyed by hand to the mixers. Further economy results because a proportion of the bagged materials, many of which do not require grinding, are unloaded from incoming transport without bag storage and double handling into the

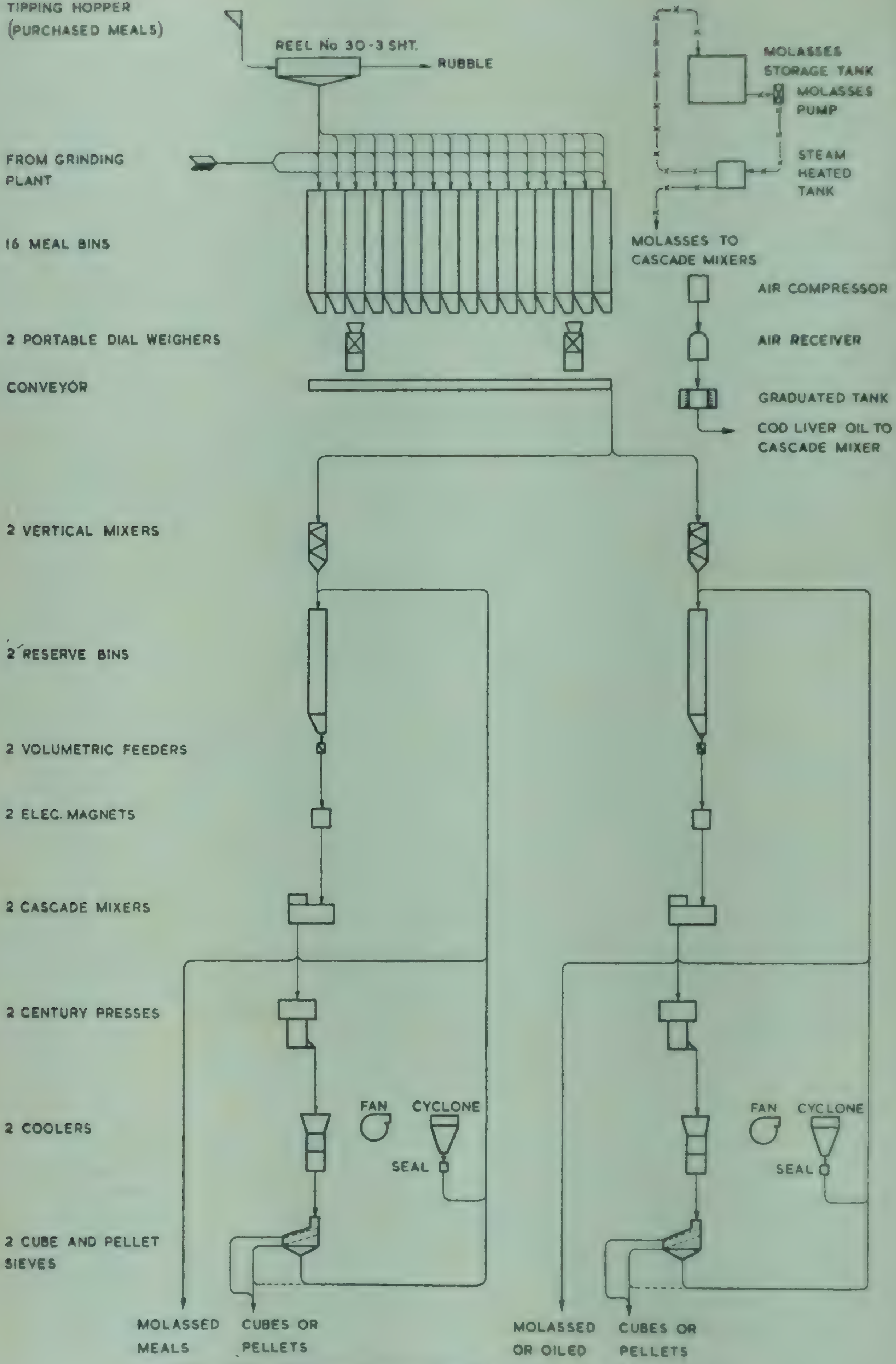

TIPPING HOPPER (PURCHASED MEALS)
REEL No 30-3 SHT.
RUBBLE
MOLASSES STORAGE TANK
MOLASSES PUMP
STEAM HEATED TANK
FROM GRINDING PLANT
16 MEAL BINS
MOLASSES TO CASCADE MIXERS
AIR COMPRESSOR
2 PORTABLE DIAL WEIGHERS
AIR RECEIVER
CONVEYOR
GRADUATED TANK
COD LIVER OIL TO CASCADE MIXER
2 VERTICAL MIXERS
2 RESERVE BINS
2 VOLUMETRIC FEEDERS
2 ELEC. MAGNETS
2 CASCADE MIXERS
2 CENTURY PRESSES
2 COOLERS
FAN
CYCLONE
SEAL
FAN
CYCLONE
SEAL
2 CUBE AND PELLET SIEVES
MOLASSED MEALS
CUBES OR PELLETS
MOLASSED OR OILED
CUBES OR PELLETS

FIG. 116.—Semi-continuous batch mixing and cubing plant.

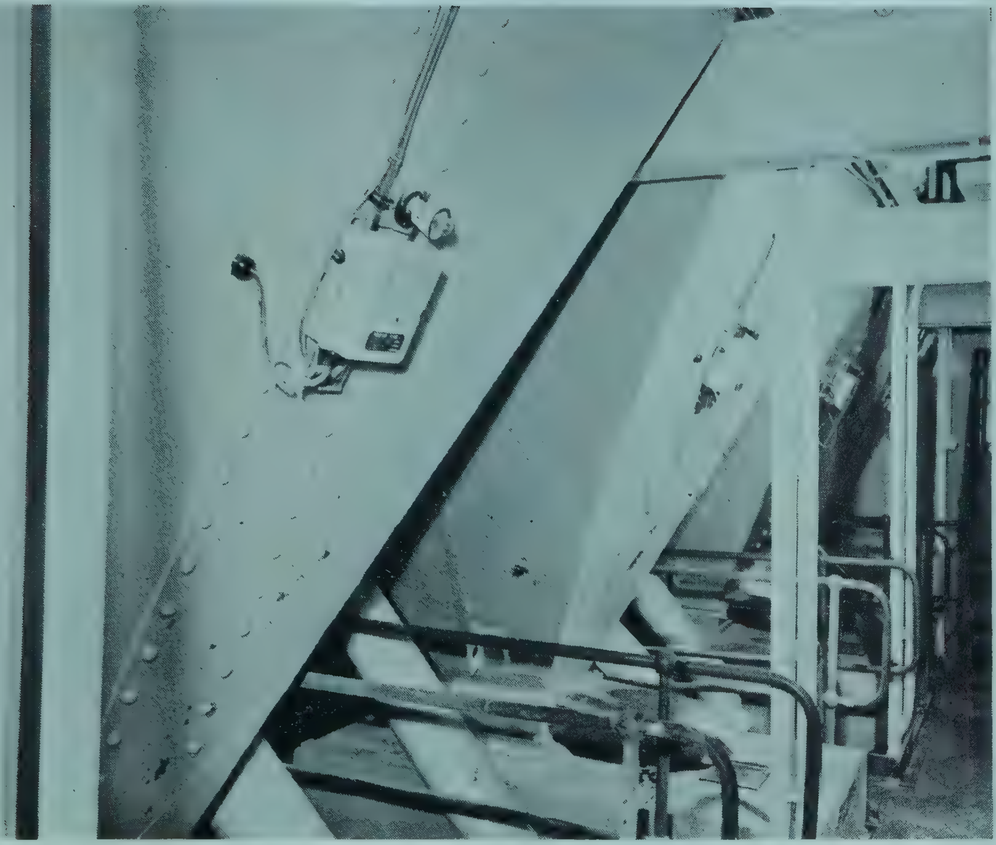


FIG. 117.—Shape of bins over portable hand-operated weigh scales.

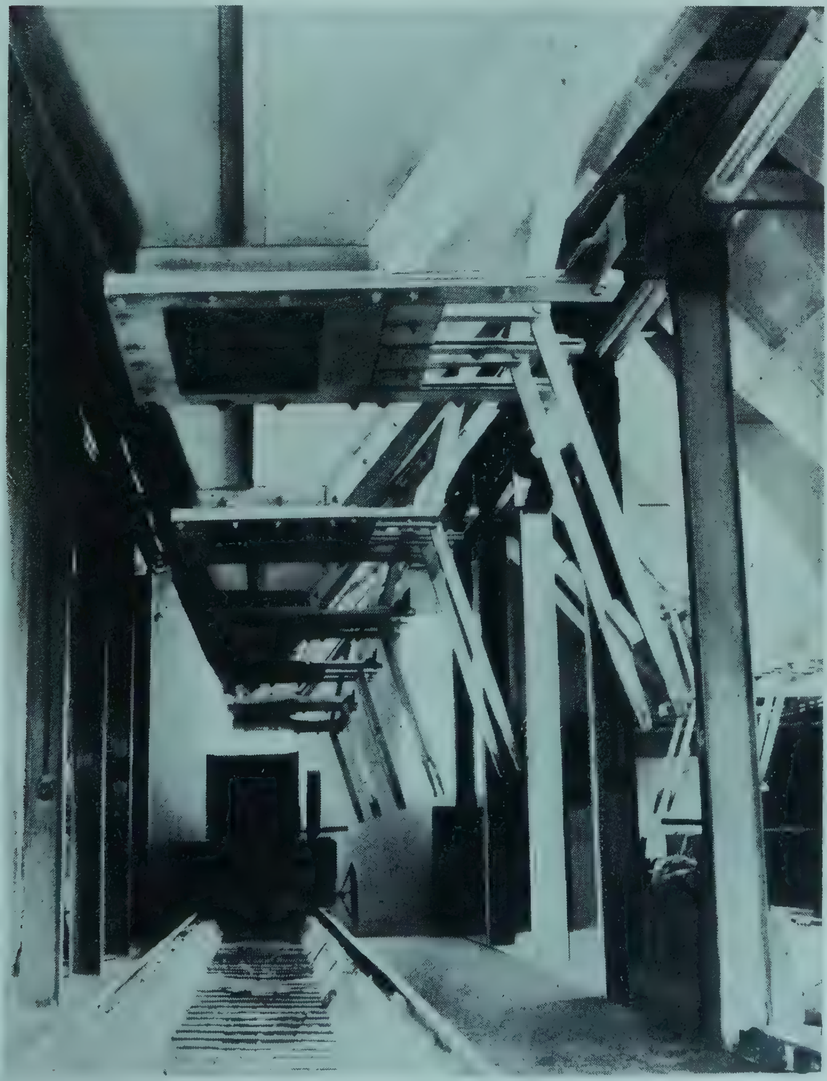


FIG. 118.—Semi-continuous blending with portable hand-operated scales.

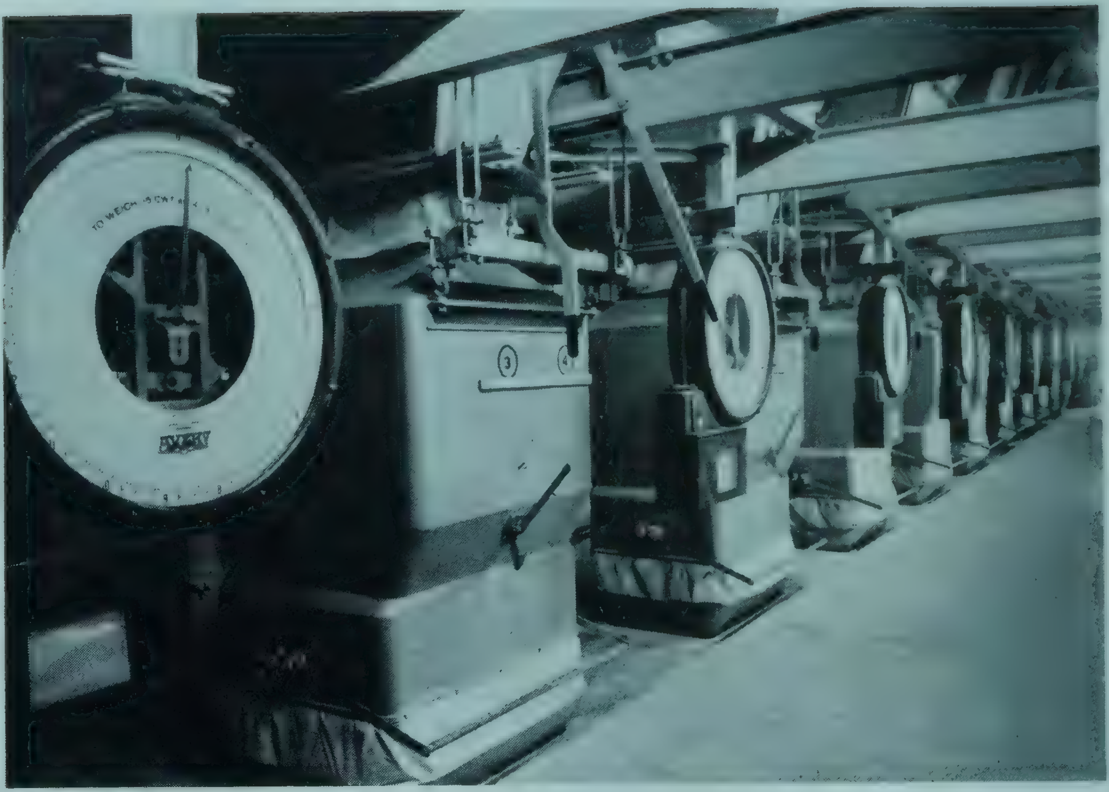


FIG. 119A.—Semi-continuous blending with fixed hand-operated weigh scales.

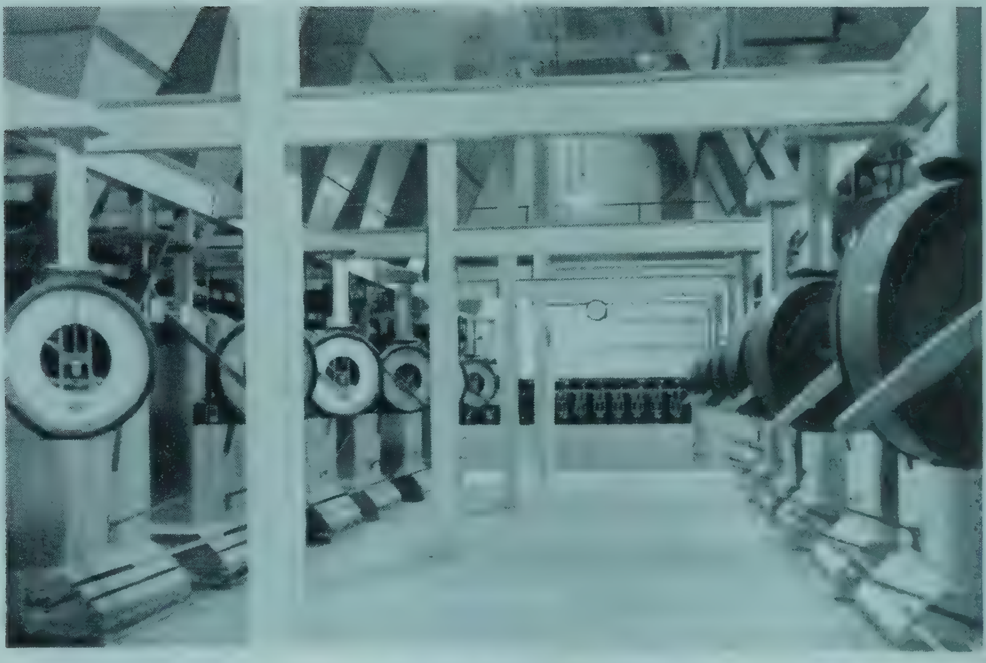


FIG. 119B.—Semi-continuous blending with fixed hand-operated weigh scales. Showing control panel for mixers, elevators and conveyors.

same range of process bins for blending with the ground ingredients. A series of conveyors are arranged over the bins so that materials may be diverted to different bins as desired, more than one material passing to the bins at the same time.

The size of meal bins is largely restricted by the nature of compound materials and the difficulty of discharging them. (See Chapter IV, Bulk Meal Storage). In this country, the large plants with an output of up to 60 tons per hour have bins of approximately 20 ton capacity for free running meals and 10 ton for non-free running meals. In the majority of cases outputs are smaller and meal bin capacities are considerably less. This means that only a proportion of the bagged materials, depending on the output of the mill, can be stored in the bins and that a certain amount of bag storage is still necessary. In many cases, however, bag storage can be reduced to a minimum by the efficient regulation of supplies.

In some large mills, all the materials are ground after mixing for the reasons explained under grinding plants (Chapter X, Grinding Before and After Mixing). In this case, the grinding bins and the meal process bins are combined in one range and the ground meal bins are eliminated, thus simplifying the layout.

(*b*) BLENDING BY PORTABLE HAND OPERATED WEIGH SCALES

The various compound ingredients may be blended from the process bins by portable hopper weigh scales (Figs. 117 and 118) which are fitted with wheels and a dial, and run on rails under the bins. The bins may be arranged in rows, each row having one and sometimes two weigh scales. Weigh scales usually have a holding capacity of 10 cwt., but in small mills some have a capacity of 3 cwt. The operator releases a bin outlet slide, designed for accurate measuring, and the material enters the hopper until the pointer registers the desired quantity on the dial; the slide is then closed and the weigh hopper, if not full, is moved to the next bin; when full, the operator opens the hopper discharge gate, thereby discharging the contents into a drag chain conveyor, contained in a trough, to accommodate the sudden rush of material, which delivers to an elevator feeding two batch mixers. The process is repeated until all the ingredients in the batch are delivered to the mixers.

(*c*) AUTOMATIC CONTROL OF BLENDING BY WEIGHT

Hand operated portable weighers are easily moved from bin to bin by the operator but electrical control may be used to advantage. The weigher may be moved, stopped and reversed at any point along its runway by a geared motor driving an endless cable over pulleys attached to the weigher. An interlock switch may be arranged to cut off the current to the motor at predetermined intervals thus controlling the movement of the weigher as desired; weighers may be stopped automatically when the batch is complete and restarted after a set interval when the mixers have finished mixing. In the same way, a system of controls may be arranged for the bin outlet slides; certain bins may be electrically locked if a particular ingredient is not required and, when a batch is complete, all the bin outlets may be locked in conjunction with the weighers until the mixer is ready to receive the next batch. Similarly, the mixing time may be controlled by another motor and period contact maker working in conjunction with the mixer outlet slides and buffer bins. Control panels with coloured lights may be arranged at any central point. Compressed air may be used to operate slides.

(*d*) Blending by Fixed Hand Operated Hopper Weigh Scales

In the semi-continuous system, fixed weigh scales of up to 10 cwt. capacity (Fig. 119) may be used; they are of similar design to the foregoing but are fitted under each bin instead of being portable. In this plant, each ingredient is weighed on its respective weigh scale, the weight being registered on its dial in the proportion required; it is then released into the mixer via the drag conveyor and elevator until the batch is complete.

The fixed weigh scale system requires more capital outlay than the portable type of plant, but the former is quicker in operation owing to the larger number of weighers and the time saved in moving them from bin to bin. It is, therefore, more suitable for mixing plants with high outputs in the neighbourhood of 30-60 tons per hour. In the portable scale system, which is slower, there is a tendency to divide the plant into smaller units, each unit having its own line of bins, weigh scales and mixers for the separate production of either compound meals, cubes or pellets. Fig. 120 shows a layout of a compound plant using this system.

(*e*) Semi-Continuous Mixing System

Drag conveyors, running in an open trough beneath the portable or fixed weigh scales, feed and deliver via an elevator, to a pair of batch mixers of suitable capacity. Under the mixers two or more buffer or reserve bins are arranged, each bin being large enough to take the whole charge from one mixer. Meal feeders or dischargers deliver the mixed material from these bins to the cubing and pelleting machines via an elevator and in the same way as the batch plant. An overflow is arranged to take the excess feed back to the bins from the top of the elevator. The mixing time may be automatically controlled as described on page 151.

Preferably the mixers should discharge directly into the buffer bins underneath them as shown in the batch plant layout (Fig. 115). If, however, there is insufficient height in the building or other layout difficulty, the mixers may discharge directly into a horizontal chain conveyor, as shown in Fig. 121. The conveyor may then deliver into an elevator feeding the buffer bins.

The Pre-mixing of Trace Ingredients

The more recent question of mixing synthetic vitamins and other trace ingredients, which are used in very small quantities, presents a number of difficulties in a plant of this kind because some of these materials are used in the proportion of ounces to a ton and many do not flow freely.

The method of tackling the problem is to employ an accurate low capacity feeder, such as the Simon Mechanical Feeder (Fig. 123) or an accurate vibrator feeder, such as the Velofeeder. In this method, the trace ingredients are first mixed in the proportion desired with the free flowing material by means of a small powder mixer of the ‘ Gardner ’ type. This increases the bulk and ensures subsequent even flowing through the feeder. This premixture is then put into the low capacity feeder from which it is blended and mixed into the compound in the main plant. The feeder may be installed over the main mixers. In this way a few ounces may be fairly evenly distributed throughout a ton.

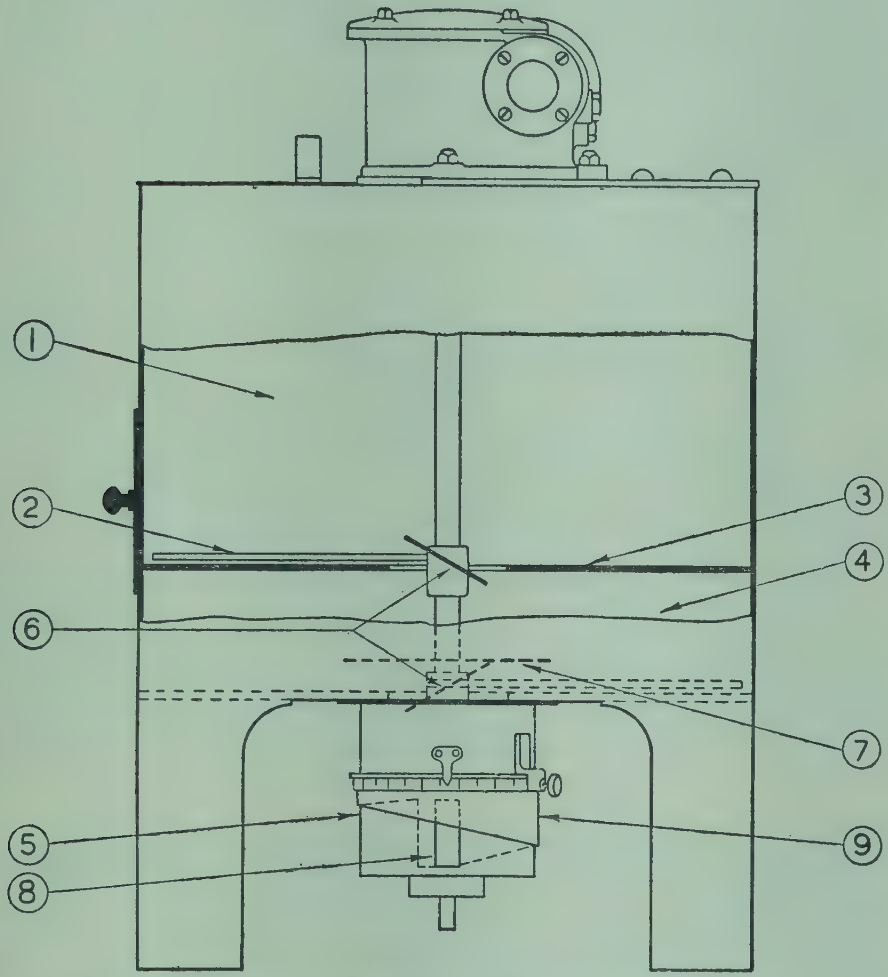


FIG. 123.—Simon mechanical feeder for trace materials.

1. Receiving chamber. 2. Revolving stirrer. 3. Partition plate. 4. Lower chamber. 5. Feeding cylinder. 6. Lifters. 7. Baffle and pressure plate. 8. Discharge slot. 9. Control sleeve.

Some materials, which are used in large proportions, may be pre-mixed with ' carrier ' meals in horizontal or vertical mixers. Materials which do not flow freely, such as Malt Culms, may also be added in this way. Alternatively, vertical mixers, which assist the discharge of materials of this nature, may be used as storage hoppers and may be arranged in line with the process bins. Sometimes these materials are tipped direct into the drag conveyor hopper from the bag, but this is, of course, a more dirty method.

(*f*) BLENDING BY A SINGLE LARGE HOPPER WEIGH SCALE

This system, which is popular in America, is the most recent type of blending system to be developed. It employs a single large hopper scale of a design similar to those already mentioned, the bins being arranged to deliver into the scale. The ingredients may be controlled from each bin either by

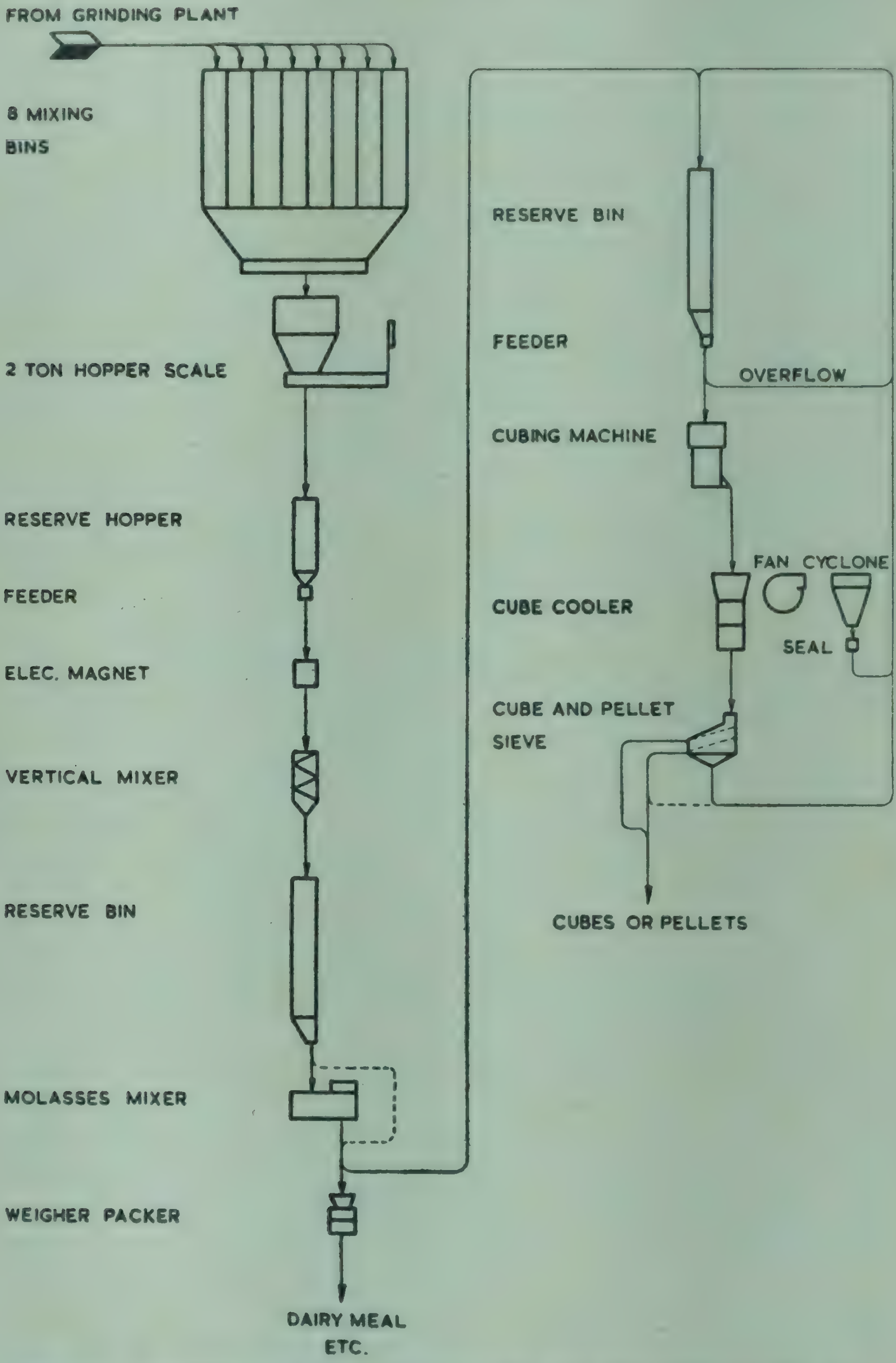

FROM GRINDING PLANT
8 MIXING BINS
2 TON HOPPER SCALE
RESERVE HOPPER
FEEDER
ELEC. MAGNET
VERTICAL MIXER
RESERVE BIN
MOLASSES MIXER
WEIGHER PACKER
DAIRY MEAL ETC.
RESERVE BIN
FEEDER
OVERFLOW
CUBING MACHINE
FAN
CYCLONE
CUBE COOLER
SEAL
CUBE AND PELLET SIEVE
CUBES OR PELLETS

FIG. 124.—Semi-continuous plant using single large fixed hand-operated weigh scale.

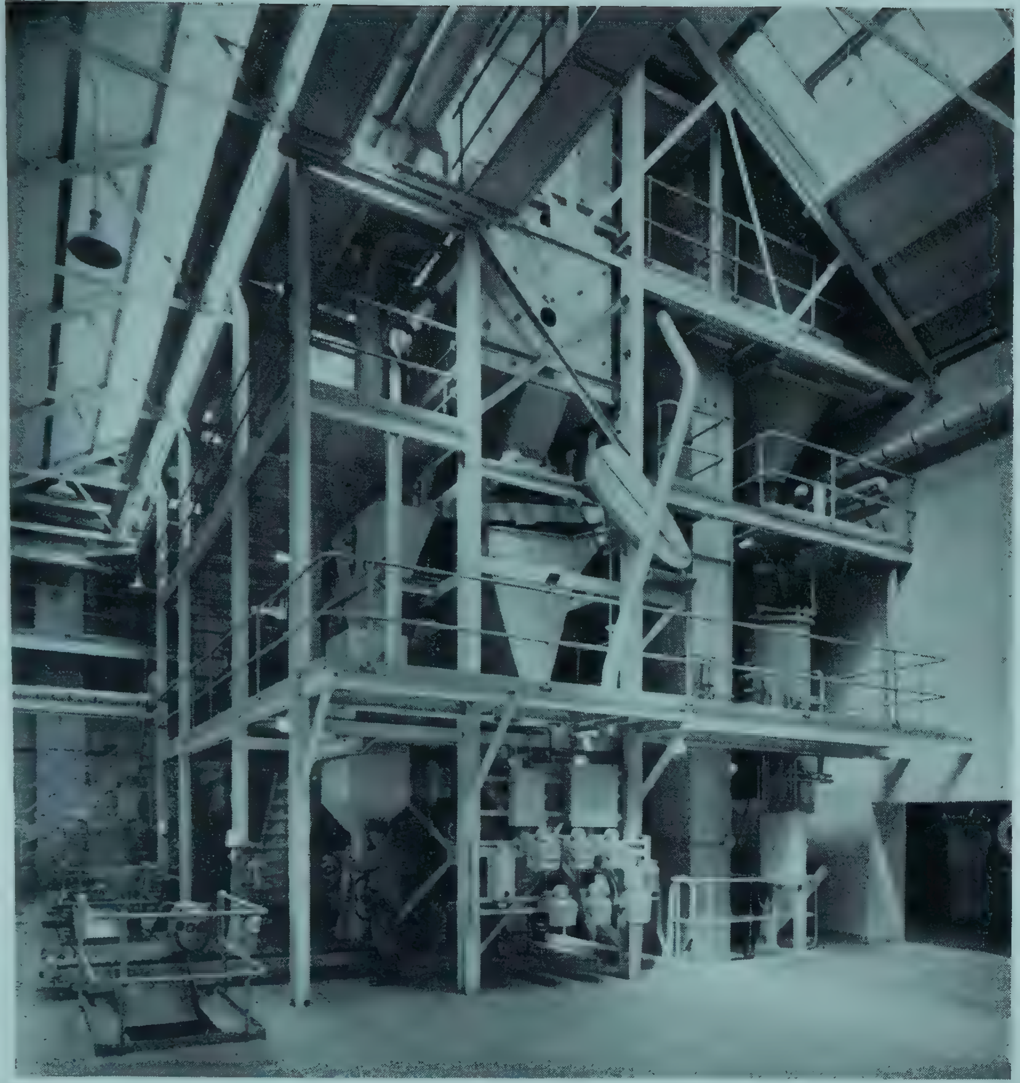


FIG. 120A.—Layout of compound plant in single storey building.

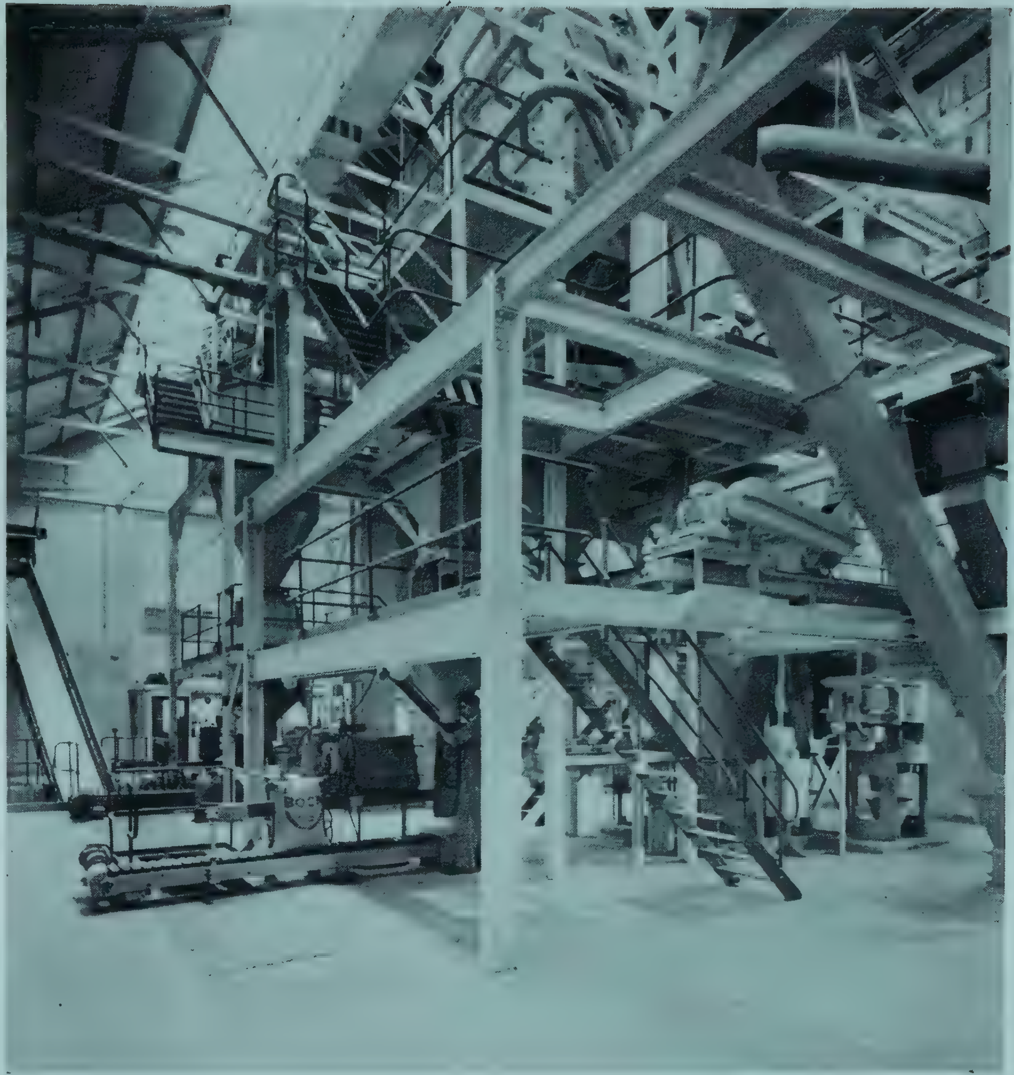


FIG. 120B.—Layout of compound plant in single storey building showing buffer bins above cubing machines.

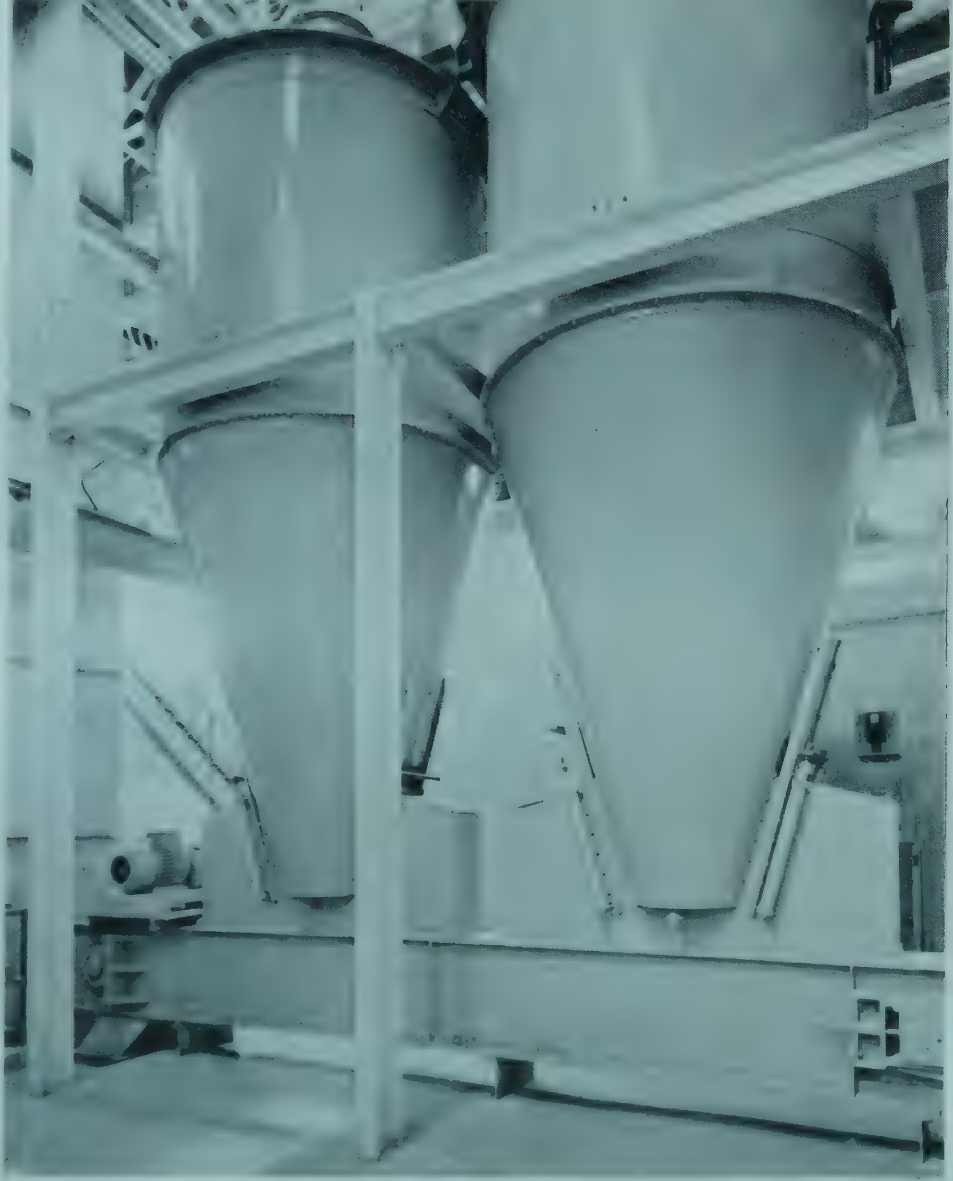


FIG. 121.—Batch mixers feeding to horizontal conveyor in a large mill.

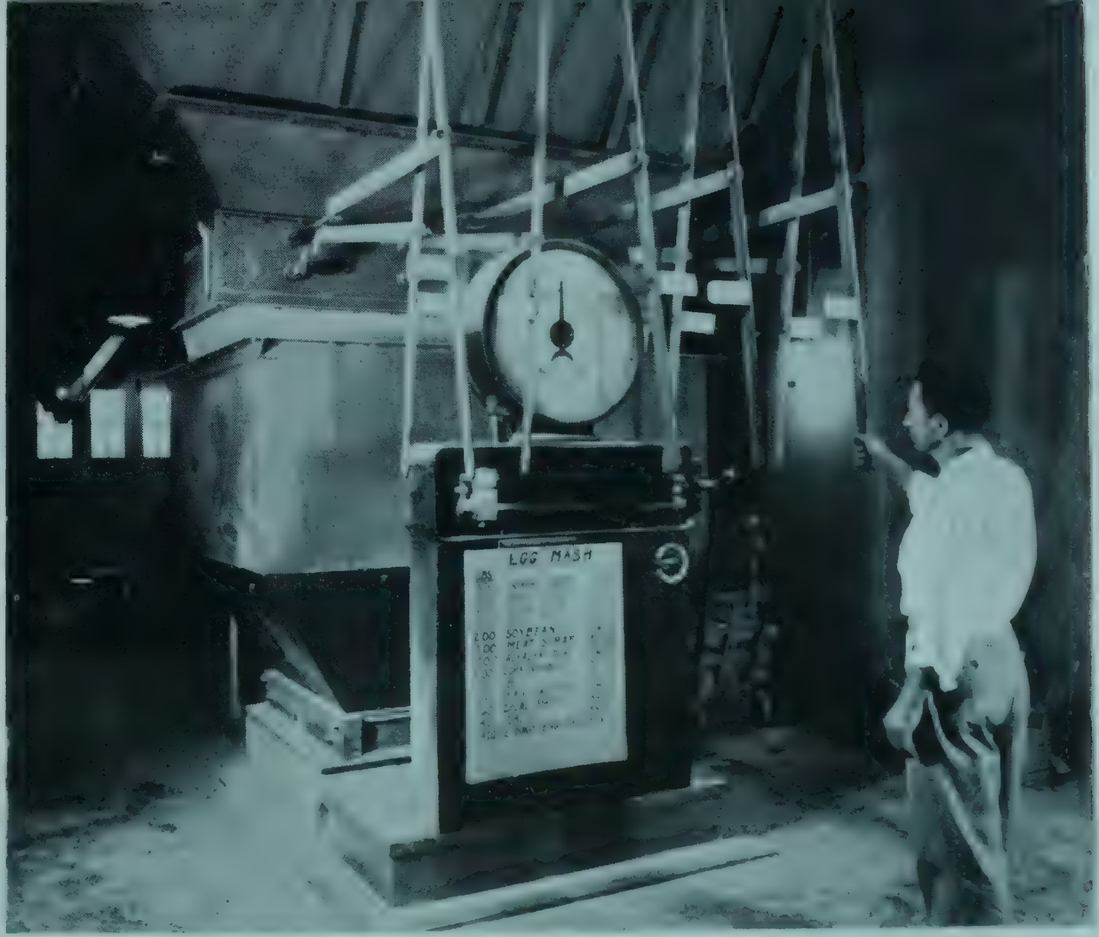


FIG. 122.—Blending with single large hand-operated weigh scale into one large weigher

hand operated slides, by electrically controlled feeders or by electrically controlled conveyors as shown in Figs. 122, 126 and 127 respectively.

In Fig. 122, which is a photograph of an American plant, there are eight bins in two rows delivering to a 2-ton hopper scale. Each ingredient is weighed in turn by the operator pulling a lever thereby opening the respective bin slide until the desired quantity of material is registered on the dial chart, which is marked off in segments. When the segments, which represent all the ingredients in the compound, have been weighed, the batch is discharged into one of two mixers underneath the scale. This batch is then mixed whilst the next is fed into the scale. Trace materials and those which do not flow freely may be fed directly into the mixers. Alternatively, a buffer bin and one mixer can be used, as shown in the flow diagram of the plant (Fig. 124).

(*g*) The Electronic Weight Control System

In Fig. 126, which shows one of the latest compound plants built in the United States, the principle is the same except that, instead of hand operated levers, feeders are employed which are driven by independent motors. A further feature is the electronic system of selecting ingredients for formulae which ensures control by a responsible person. In this particular mill, the entire operation of the whole system can be controlled by one man and, as mixed compound meals are stored in bulk and delivered to bulk wagons, the total staff of the mill, which is capable of an output of 20 tons per hour, is four men.

It will be observed that this illustration shows a plant with eight bins grouped round the scale. This number can sometimes be increased whilst maintaining the angle of fall into the scale. In this country, however, where about 20 bins are normally required for the various ingredients, it is usually necessary to convey from some distance away, as shown in Fig. 127. A feature of the electronic setting of the weight of each ingredient is that a vernier situated under each dial on the control panel can be set to compensate for the amount of material in transit between the feeder and the scale when the electronic cut-off operates.

On the other hand, this type of blending system is initially expensive, particularly when conveyors have to be used. As all conveyors feed the scale independently, each has to be a slightly higher capacity than that of the complete plant. Also, the building has to be higher than with other types of plant in order to accommodate the scale and mixers under the bins, and some additional supporting structure is involved. Provided that these difficulties are satisfactorily overcome, however, the plant is extremely efficient.

AUTOMATIC CONTINUOUS PLANTS

In automatic continuous compound plants, the ingredients may be blended and mixed either by volume or by weight.

(*a*) Continuous Blending by Volume

1. *Diagram*

Fig. 125 shows a flow diagram designed by Henry Simon Ltd. of an automatic volumetric continuous plant capable of 10 tons per hour of

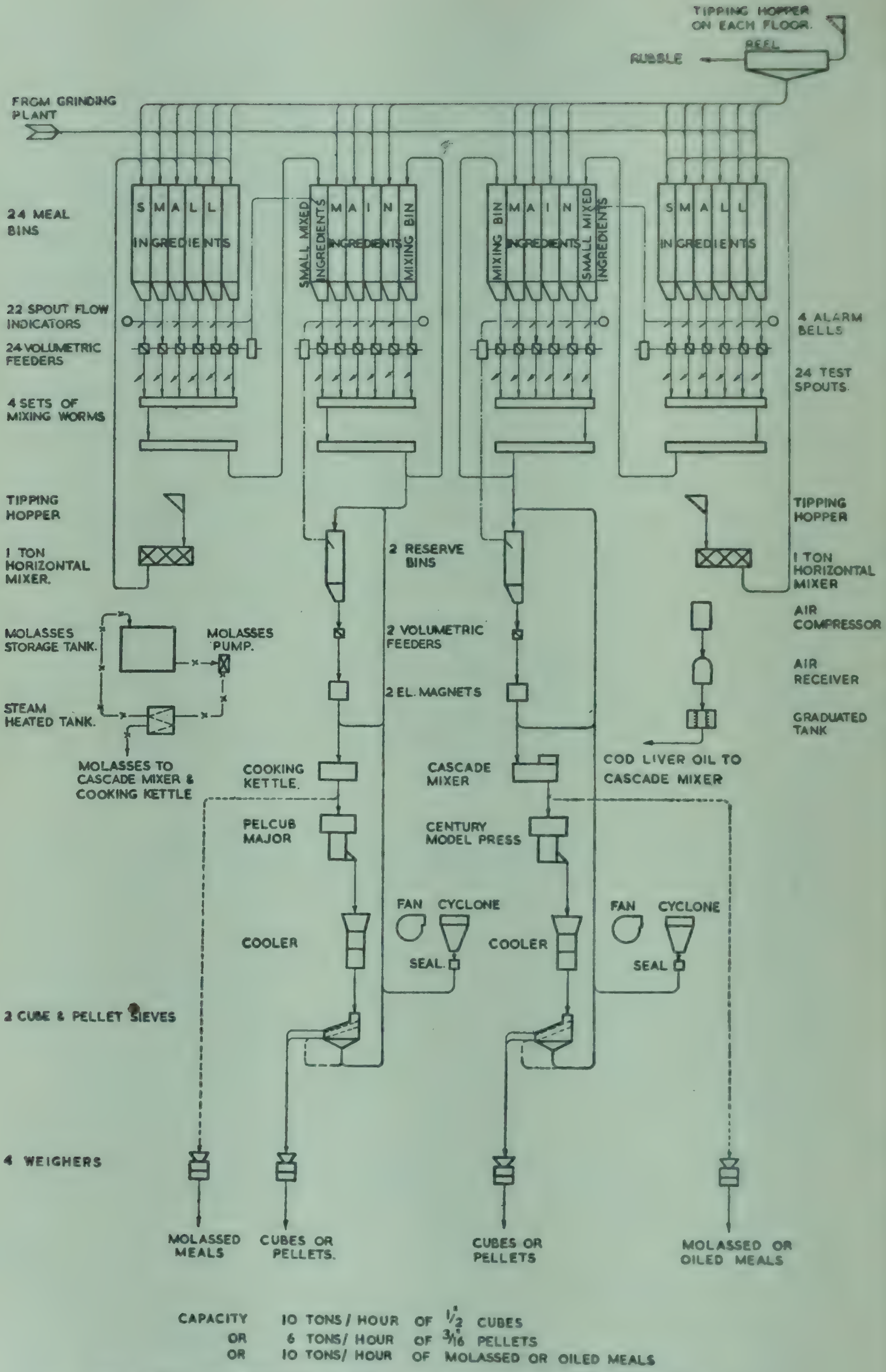

TIPPING HOPPER ON EACH FLOOR.
REEL
RUBBLE
FROM GRINDING PLANT
24 MEAL BINS
SMALL INGREDIENTS
SMALL MIXED INGREDIENTS
MAIN INGREDIENTS
MIXING BIN
MIXING BIN
MAIN INGREDIENTS
SMALL MIXED INGREDIENTS
SMALL INGREDIENTS
22 SPOUT FLOW INDICATORS
24 VOLUMETRIC FEEDERS
4 SETS OF MIXING WORMS
4 ALARM BELLS
24 TEST SPOUTS.
TIPPING HOPPER
1 TON HORIZONTAL MIXER.
2 RESERVE BINS
TIPPING HOPPER
1 TON HORIZONTAL MIXER
MOLASSES STORAGE TANK.
MOLASSES PUMP.
2 VOLUMETRIC FEEDERS
AIR COMPRESSOR
AIR RECEIVER
2 EL. MAGNETS
STEAM HEATED TANK.
GRADUATED TANK
MOLASSES TO CASCADE MIXER & COOKING KETTLE
COOKING KETTLE.
CASCADE MIXER
COD LIVER OIL TO CASCADE MIXER
PELCUB MAJOR
CENTURY MODEL PRESS
FAN
CYCLONE
FAN
CYCLONE
COOLER
SEAL.
COOLER
SEAL
2 CUBE & PELLET SIEVES
4 WEIGHERS
MOLASSED MEALS
CUBES OR PELLETS.
CUBES OR PELLETS
MOLASSED OR OILED MEALS
CAPACITY 10 TONS / HOUR OF 1/2" CUBES
OR 6 TONS/ HOUR OF 3/16" PELLETS
OR 10 TONS/ HOUR OF MOLASSED OR OILED MEALS

FIG. 125.—Fully automatic continuous volumetric mixing and cubing plant.

compound meals, cubes or pellets, and Fig. 132 shows a layout plan of the same plant. In this plant, all the ingredients are delivered from the grinders and from incoming transport into a range of process bins in the same way as in the semi-continuous batch plant. In this case, however, the portable or fixed weigh scales are replaced by a range of automatic feeders which blend the ingredients by volume. The feeders discharge the ingredients into a series of mixing worm conveyors which deliver to elevators and buffer bins feeding the cubing and pelleting machines. No batch mixers are necessary, the mixing worms are arranged to give the maximum mixing effect and a continuous mixer, although essentially a molasses or cod liver oil mixer and, in this case, attached to the cubing machine, gives a final mixing to the dry ingredients.

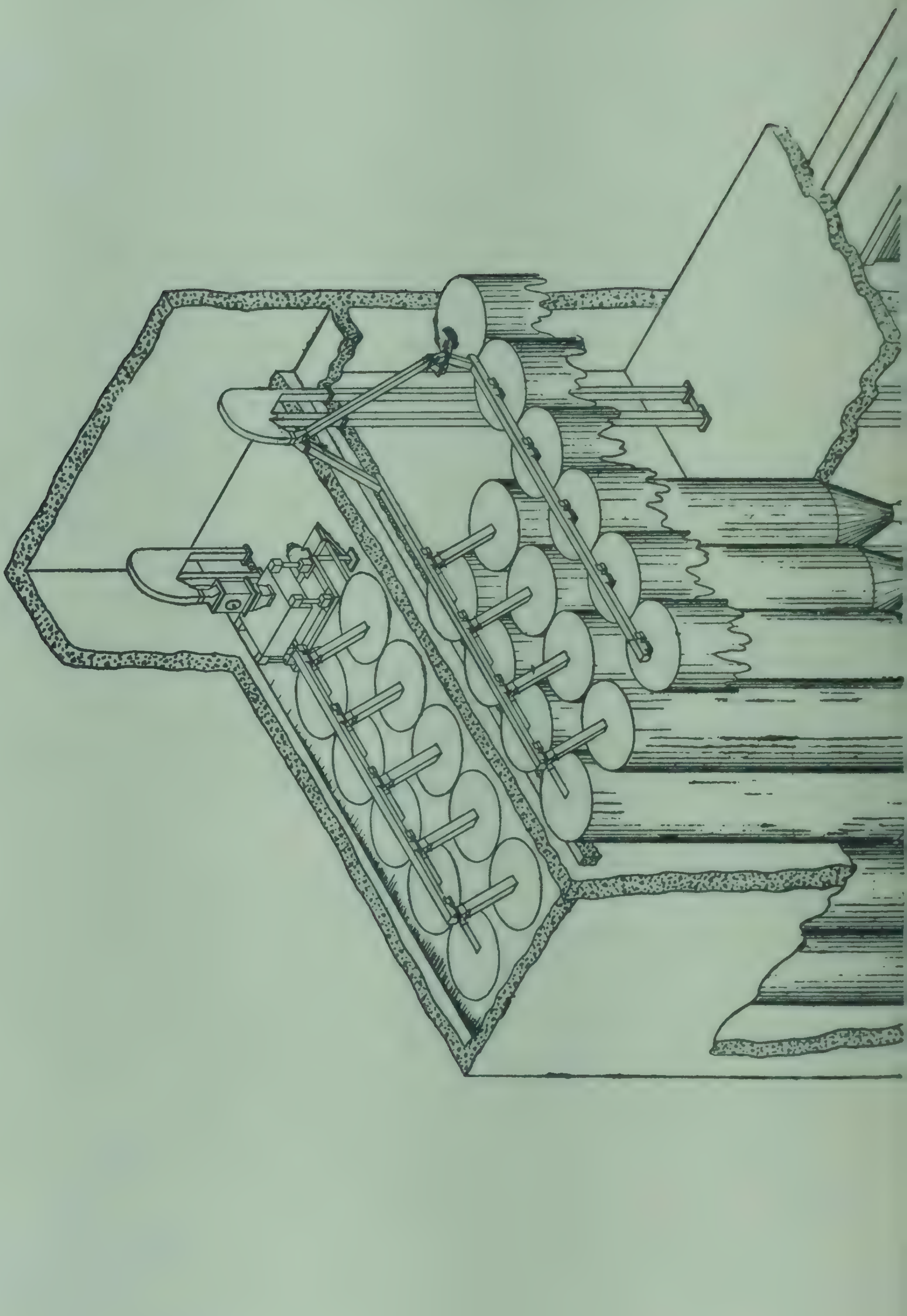
In Fig. 125, two separate plants are shown so that cubes or pellets may be manufactured at the same time. The bins of each plant are arranged in series side by side, the left hand series having bins of smaller capacity for ingredients used in the compound in small percentages, the right hand series having bins of larger capacity for ingredients used in larger percentages. The small percentage ingredients are blended and mixed by the left hand feeders and mixing worm and elevated to one or more of the larger right hand bins. This pre-mixture is then again blended and mixed with the larger percentage ingredients, which are fed direct to the right hand bins. In this way, the small percentage ingredients receive a double blending and mixing; these consist of some of the most expensive in the ration as, for example, mineral mixtures and fish meal which it is important should be mixed throughout the whole as intimately as possible. In the case of the large percentage ingredients, any inaccuracy caused by variation in the density of the material, does not upset the balance or cost of the compound to the same extent.

Another reason for the double series of bins is to ease the difficulty of discharging the small percentage ingredients, most of which do not flow freely and are consequently prone to arch in the hoppers; the arrangement allows the first series to be discharged at a much higher rate because it is only from the second series that the complete compound is blended; if the compound is blended from one series, smaller hoppers and feeders are required for the small percentages, thus accentuating the difficulties of ensuring a free flow and increasing the range of feeders.

Trace materials and the worst flowing materials may be pre-mixed with ‘ carrier ’ meals before delivery to the bins in the same way as described in detail in the semi-continuous system. In fact, all the small percentage ingredients may be pre-mixed on the batch principle into one or two of the main bins, thus eliminating the first series of bins altogether. This is more usual in the latest plants because it is simpler and considerably reduces the number of bins. (See page 166.) Similarly, low capacity feeders containing pre-mixtures of trace ingredients may be fed directly into the main mixing worms.

2. *The Volumetric Meal Feeder*

This machine (Fig. 129) is designed by Henry Simon Ltd. specifically for continuous plants; it consists of a revolving drum driven by a shaft



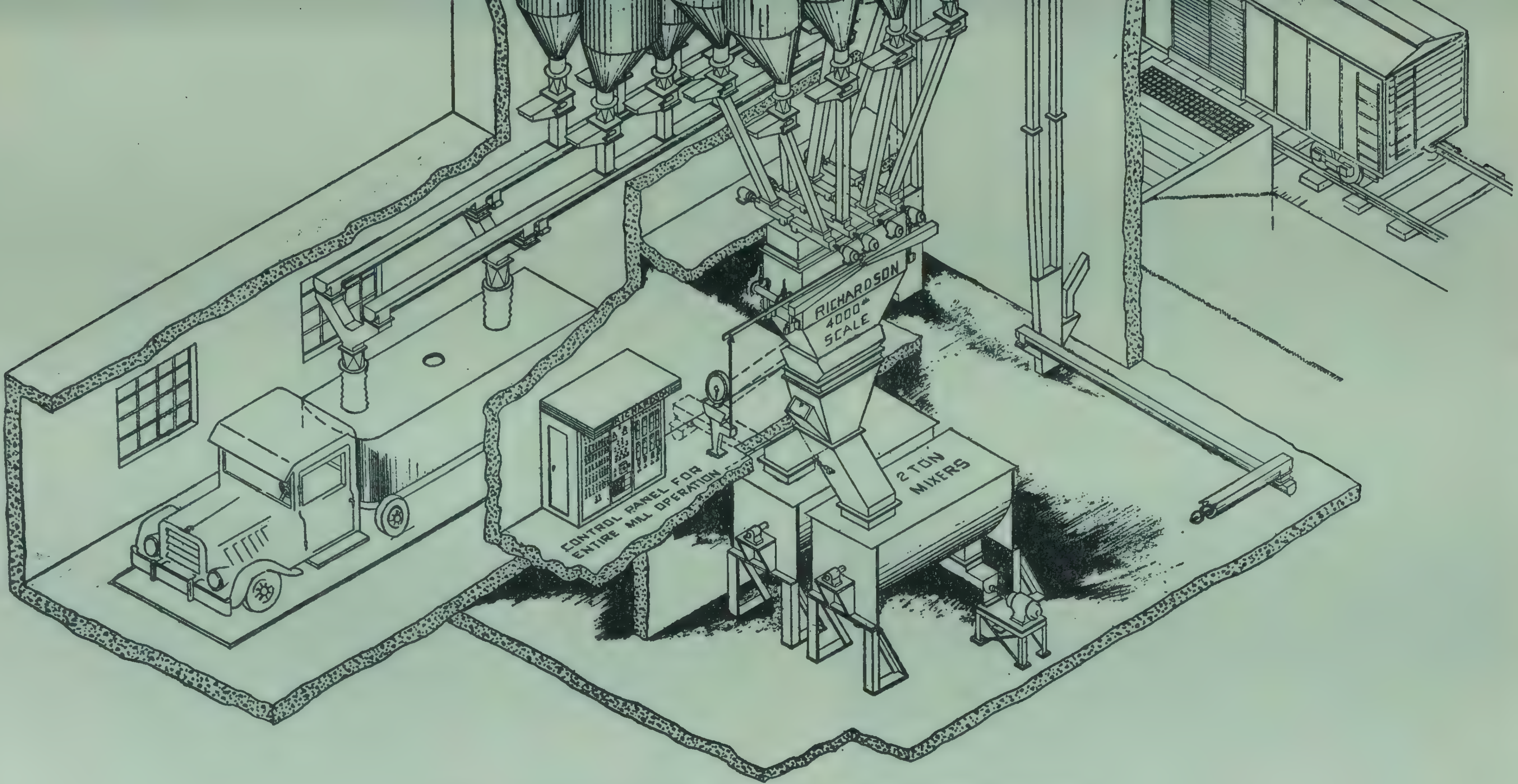

RICHARDSON
4000
SCALE
2 TON
MIXERS
CONTROL PANEL FOR
ENTIRE MILL OPERATION

FIG. 126.—The electronic weight control system using gravity discharge.

through a ratchet mechanism. The drum contains a number of staggered pockets arranged so that one pocket delivers its contents immediately after the other, thus ensuring a continuous delivery stream.

A spiral baffle plate fitted to the delivery end of the drum and on the opposite spiral to the pockets, further obviates any rush of material between the delivery of each pocket so that the stream of feed is sufficiently continuous even on the slowest revolutions of the drum. If accurate blending is to be obtained by a line of feeders delivering into a mixing worm, it is important that the stream from each feeder should be constant even though varying in quantity. A gap in the delivery of any one feeder would mean that parts of the continuous stream passing along the worm would not contain that particular ingredient.

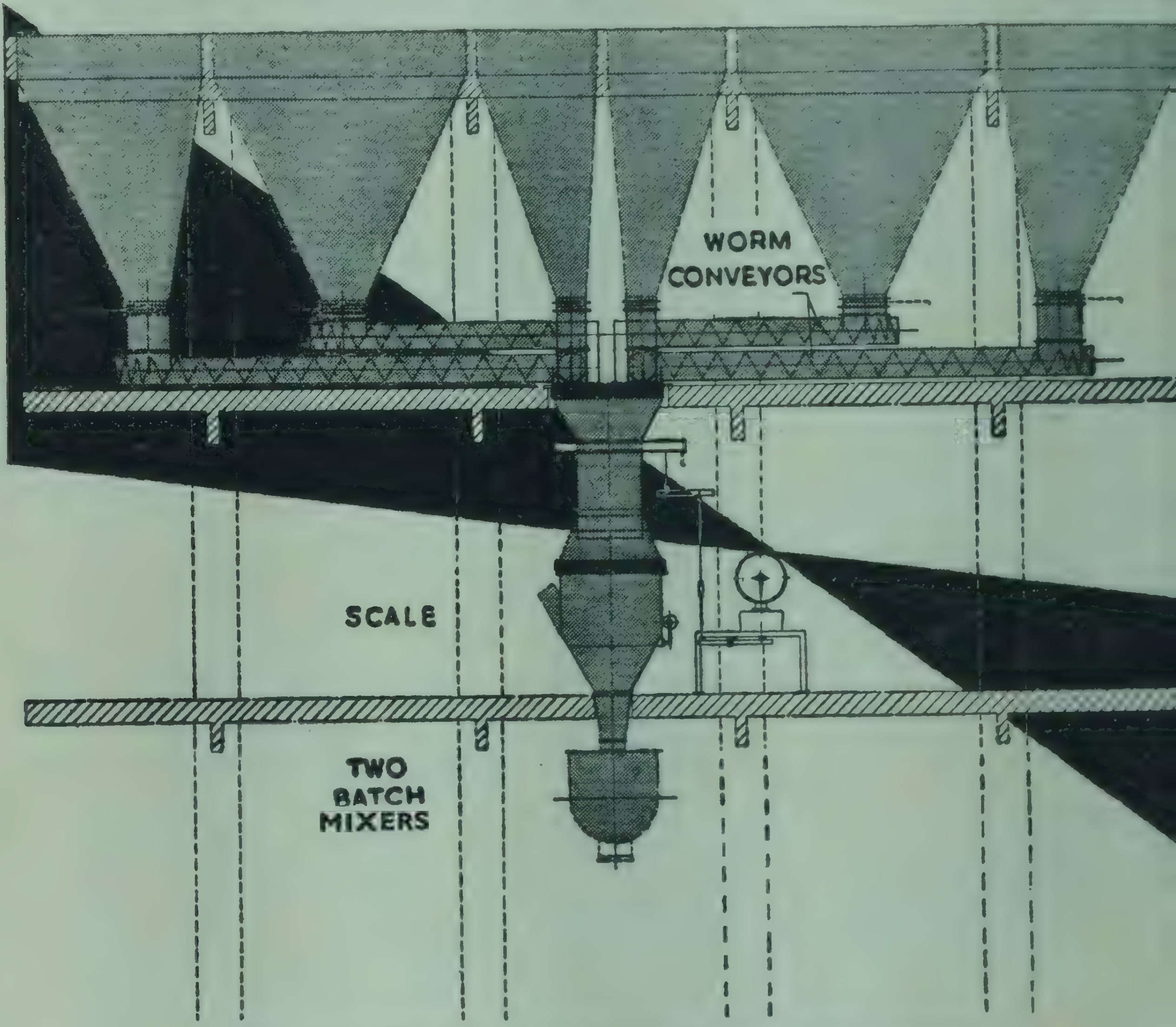
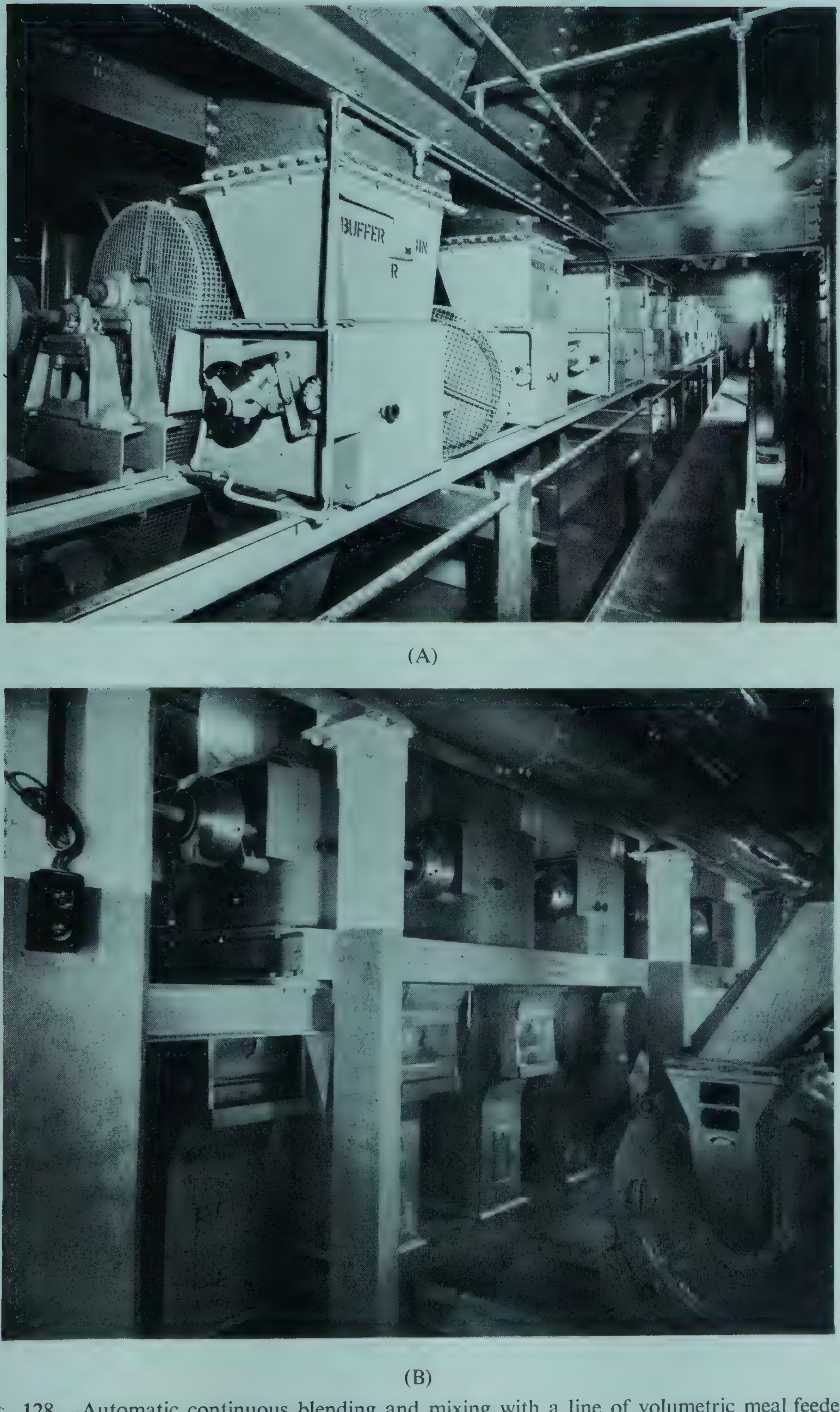


Fig. 127.—The electronic weight control system using conveyors.

The adjustable ratchet mechanism alters the speed of the drum and varies the rate of feed from 250 lb. to 5 tons per hour, when working at a speed of 40 r.p.m. on compound materials weighing 30 lb. per cubic ft. The range of output, which is indicated by a calibrated scale, can be varied by altering the speed of the driving shaft. The feeder can be very accurately


BUFFER BIN
R

(A)

(B)

FIG. 128.—Automatic continuous blending and mixing with a line of volumetric meal feeders

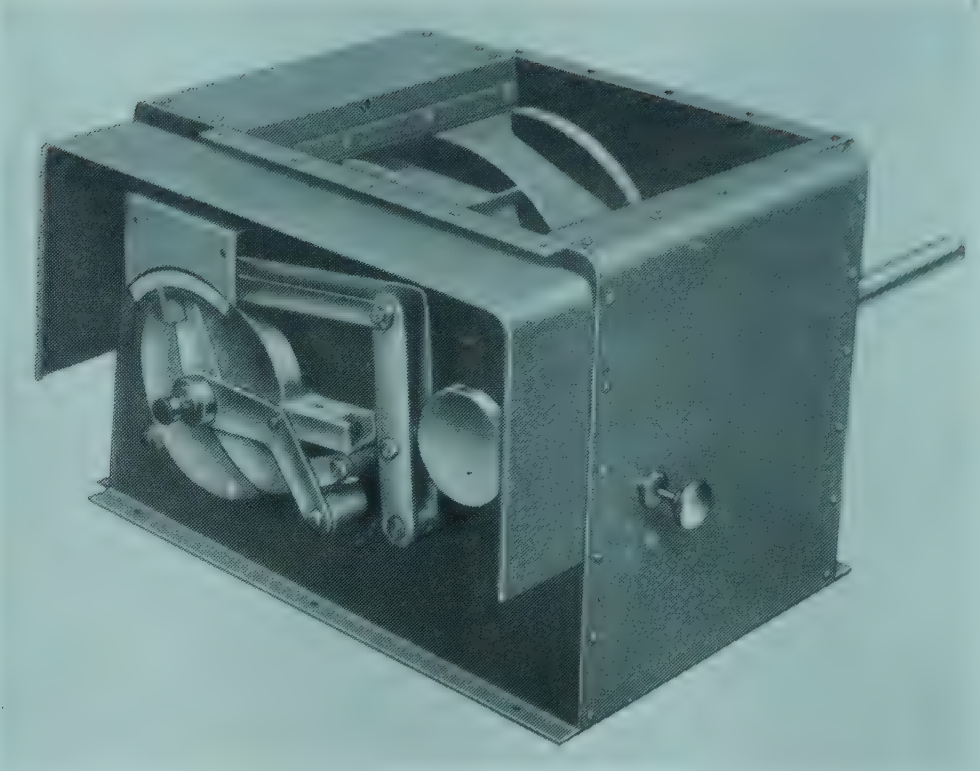


FIG. 129.—Simon volumetric meal feeder.

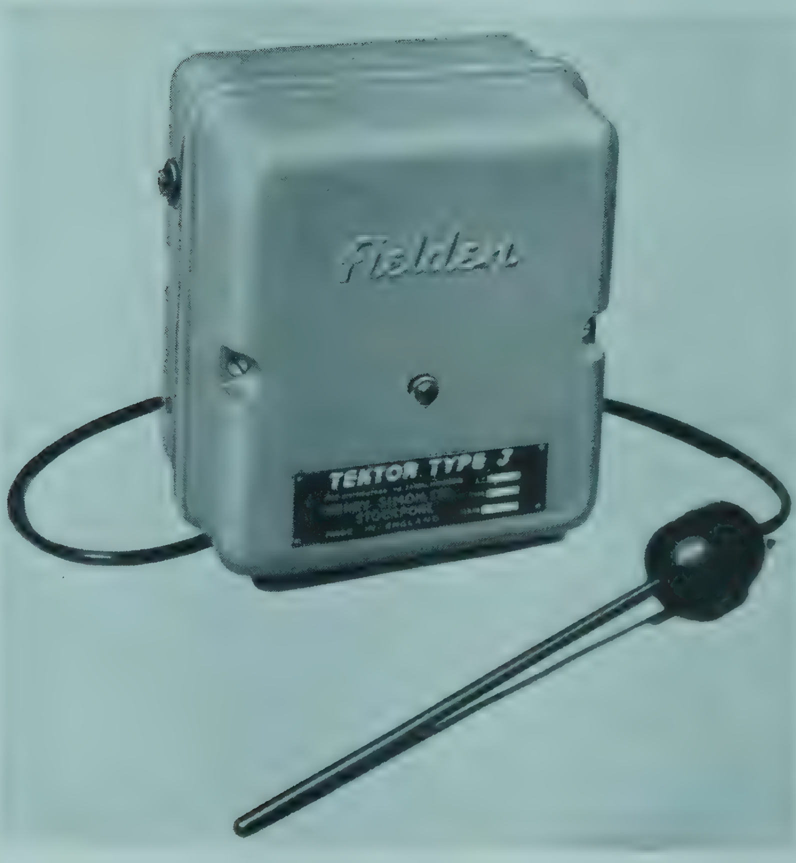

Fielden
TEKTOR TYPE J
SIMON
STOCKPORT
ENGLAND

FIG. 130.—Tektor high and low level indicator.

set at any point within the above range owing to the design of the ratchet mechanism. On feeders operated by toothed ratchet wheels, precision of setting is limited by the distance between the teeth. On the Simon feeder, however, the ratchet wheel is quite smooth and contains no teeth; it is revolved by an arm containing a block which is adjustable to prevent the arm slipping over the smooth surface of the wheel.

The ‘ Draver ’ feeder, which is made in several sizes, and widely used in America, is designed on lines similar to the Simon feeder. It has pockets of varying designs suitable for a number of materials. Another feeder, known as the Smith mixer, may also be used in this type of plant; it is suitable for materials that will not flow freely because an agitator, incorporated above the worm, helps to break up any arching.

3. *Automatic Control of Blending by Volume*

In continuous volumetric plants, automatic control may be arranged to ensure that as long as the plant is working all types of ingredients are being delivered from their respective bins in predetermined proportions, thus maintaining a correctly blended compound at all times. In Fig. 132, two lines of feeders and the mixing worms are driven by a 17½ h.p. motor from a countershaft. A separate stop and start device, connected electrically to the motor, controls the feeders of each set of bins, namely, two sets of small ingredients bins and two sets of large. Low level indicators, connected electrically to the stop and start devices, are installed in the spouts between the bin hoppers and the feeders so that if the feed runs off any feeder, either through the bin becoming empty or because of the arching of the material in the hopper, all the feeders are stopped automatically. In other plants of this type, a separate motor may be arranged to drive each set of feeders, usually five to eight in number, the indicators being connected electrically to the motors; in these cases the stop and start devices are not used.

A system of warning lights or bells may be connected from a central panel so that, if any bin runs off, the operator is notified immediately. High level indicators may be installed in the large bins receiving the small percentage pre-mixtures to warn the operator when the bins are full. A similar arrangement can be provided between the mixing worms and the buffer bins feeding the cubing machines.

Fig. 131 shows a typical installation using high and low level indicators in three bins. The high level indicators are arranged to ring the alarm bell and light the appropriate pilot lamp on the indicator panel. By pushing the alarm cancel button below the lamp, the bell is silenced but the lamp remains on until the material leaves the indicator probe.

The low level indicators are arranged for similar operation but, in addition, they energise a timing device, which stops the motor of the measurer after a pre-set time, thus preventing faulty blending if the operation fails to change over before the bin concerned has completely emptied.

The indicators, shown in Fig. 130, are Tektors distributed by Henry Simon Ltd. This is a simple device consisting of an electronic capacity relay with flexible connection to a probe. The unit operates by building up an electrical field about the probe and the approach or withdrawal of any mass in relation to that field causes a change in capacity. It is quite

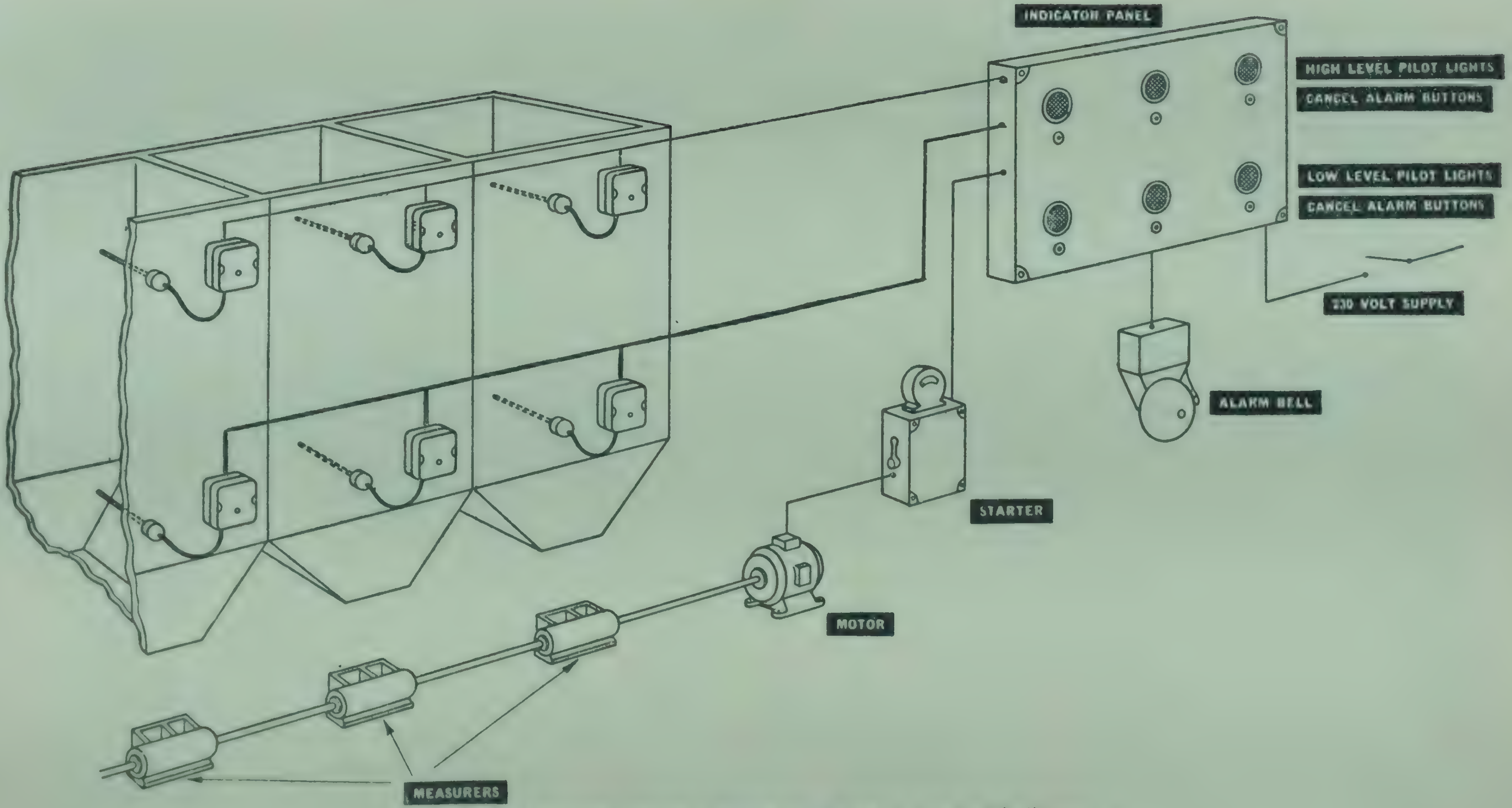

INDICATOR PANEL
HIGH LEVEL PILOT LIGHTS
CANCEL ALARM BUTTONS
LOW LEVEL PILOT LIGHTS
CANCEL ALARM BUTTONS
230 VOLT SUPPLY
ALARM BELL
STARTER
MOTOR
MEASURERS

FIG. 131.—Automatic control system with high and low level indicators.

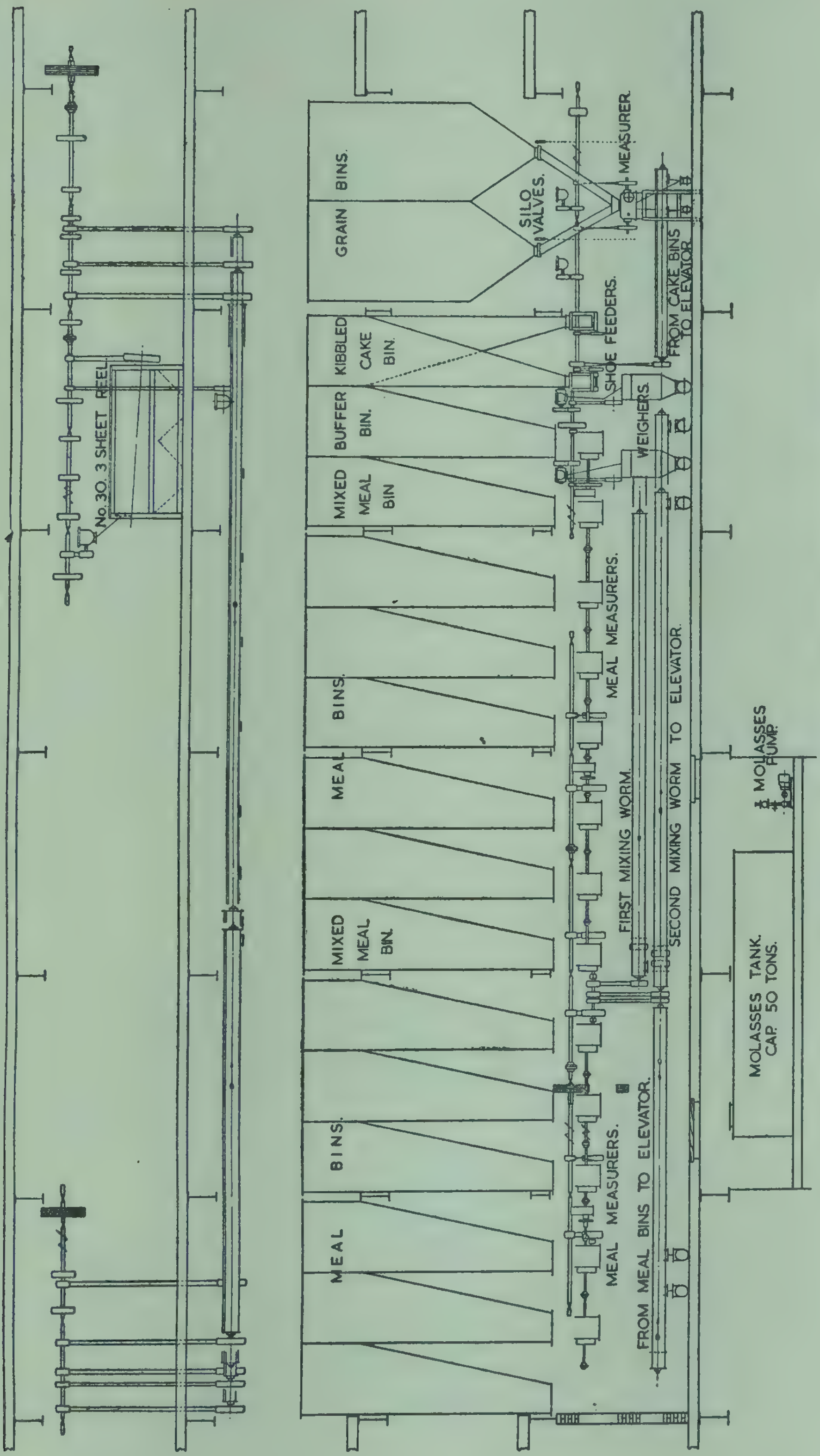

GRAIN BINS.
SILO VALVES.
MEASURER.
FROM CAKE BINS TO ELEVATOR
SHOE FEEDERS.
KIBBLED CAKE BIN.
BUFFER BIN.
WEIGHERS.
MIXED MEAL BIN
No. 30. 3 SHEET REEL.
MEAL MEASURERS.
FIRST MIXING WORM.
SECOND MIXING WORM TO ELEVATOR.
MEAL BINS.
MOLASSES PUMP.
MOLASSES TANK. CAP. 50 TONS.
MIXED MEAL BIN.
MEAL BINS.
MEAL MEASURERS.
FROM MEAL BINS TO ELEVATOR.

FIG. 132.—Continuous blending and mixing with line of volumetric feeders layout.

unnecessary for the probe to establish contact with the material and there is no risk of spark or fire.

The Tektor is easy to install by making a hole in the bin wall, and it will work indefinitely without attention on most dry materials and liquids

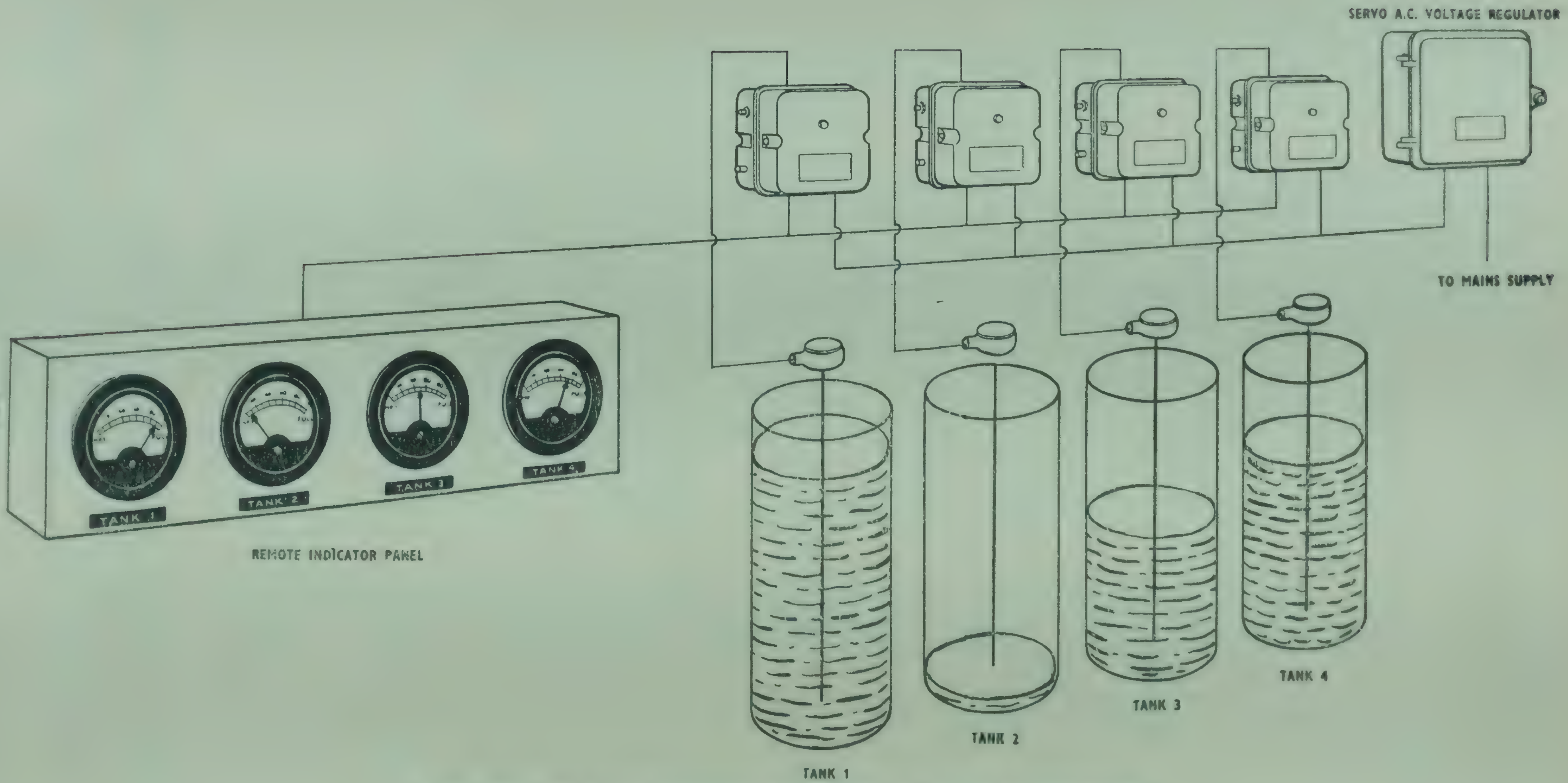

SERVO A.C. VOLTAGE REGULATOR
TO MAINS SUPPLY
TANK 1
TANK 2
TANK 3
TANK 4
REMOTE INDICATOR PANEL

FIG. 133.—The Telstor continuous level indicator—typical arrangement.

because the material cannot hang up on the probe as sometimes occurs with flap or valve controls. It has a number of applications in compound and auxiliary plants.

A natural development of the Tektor is the Telstor (Fig. 133) which has been designed to continually indicate the level of the material in the bin. The probe, in this case, usually consists of a flexible cable, which extends the full depth of the bin, the level of the contents being indicated on a meter mounted on an adjacent control point. Where a number of bins are fitted with Telstors, the meters can be mounted on a central panel in the same way as the pilot lights in the case of Tektors.

4. *Test Weighing*

In a continuous volumetric system, it is desirable to check the density of the ingredients. This is particularly important when a new ingredient is introduced into the ration, but it is advisable at all times to carry out tests at regular intervals because the density is apt to vary. Forked by-pass spouts may be arranged under each feeder so that the measured feed can be turned off by a valve before the mixing worm and weighed.

Material for testing need only be drawn off over 15 or 30 second periods and a simple arrangement is to have a weigher on wheels which can be easily moved by the operator from one bin to another, Another method is to have a container of known weight, large enough to hold 30 seconds run of any of the ingredients, and of convenient size to be moved by the operator to a fixed platform weigher in a central position. An electric clock should be installed where it can be clearly seen whilst collecting the test samples.

A more elaborate system automatically tests all the feeders at the same time. In this system, which is quicker, more exact, and saves labour compared with the foregoing, all the turn-over valves are electrically operated from a central control, thereby turning the measured material from each feeder into its own container in one operation. The duration of the testing period can be controlled by a meter, and when this has expired, the turn-over valves are automatically returned to their normal position for delivering to the mixing worms.

5. *Continuous Mixing*

In Fig. 132, each set of mixing worms from the second or right-hand series of bins in each plant gives the main mixing to the blended ingredients; they are arranged to give the maximum mixing effect, the top worm in each plant travelling to the left and collecting and conveying all the ingredients to the bottom worm which travels in a right-hand direction. It should be noted that when starting up and until the feeders have been working a few minutes, the ingredients in the left-hand bins in the row will not be able to catch up and mix with those in the end right-hand bins before the latter leave the mixing worms. To prevent this, an extra bin, fed from the mixing worm, may be provided to receive this unmixed feed until the mixture is ready for the cubing plant. This bin, which is provided with another feeder, is also useful for gradually mixing back any chokes or sieved floor sweepings into the main system.

The mixing worms may be arranged in various ways: they may deliver in the centre so that the ingredients from the bins at each side meet, or one long worm may be arranged with delivery at one end; in the latter case, the end right-hand bin must not be less than 10 ft. from the end of the worm. This allows for reasonable mixing after all the ingredients have been collected. In many cases, there are two or three rows of worms under the respective rows of bins delivering to a common cross worm which in turn delivers to an elevator.

Once all feeders are working correctly, and have been running for a few minutes, a slide is drawn at the end of the mixing worms, thereby diverting the blended compound from the mixing bin to the buffer bins. The level of material in the buffer bin is controlled automatically. Volumetric feeders deliver the compound from the buffer bins either direct to the packers for weighing and sacking off as a compound meal, or to the cubing and pelleting machine. An overflow returns to the buffer bin in the same way as described in other plants. In plants using a number of cubing and pelleting machines, a proportionately larger number of buffer bins are beneficial, because, if a reserve of mixed material of different formulae is available, the plant is more flexible and machines can be changed over more quickly.

In the plant shown in Figs. 125 and 132, a continuous cascade mixer, as described in the Mixing chapter, gives a final mixing to the various meal ingredients and also mixes molasses and cod liver oil by atomisation.

Other methods of continuous volumetric blending by pre-mixing. Continuous blending plants may be arranged on quite different lines to the plant described above. The object in these cases is to reduce the number of bins, thereby lowering overhead costs, simplifying the plant and increasing flexibility.

This may be done by carrying pre-mixing a stage further. Cereals of similar characteristics, oil cakes of similar characteristics and so on may be pre-mixed into the process bins so that the number of ingredients to be finally blended by the feeders is considerably reduced.

In this way, very few bins are required and changing over from one type of ration to another is simplified. A number of varieties of this type of plant may be employed according to the type of building. It will be seen, therefore, that continuous volumetric blending can be arranged on flexible lines to suit a large number of circumstances.

(*b*) CONTINUOUS BLENDING BY WEIGHT

A number of fully automatic weighers for blending each ingredient of compound rations are not often used owing to their elaborate nature and high capital cost ; at present, they are confined to one or two high capacity plants in which they weigh the large percentage ingredients only, the remainder being blended by simple hand operated weigh scales. This system should not be confused with the electronic weight control system in which one large weigher is used for all the ingredients.

The necessity for an elaborate design of weigher and automatic control system is due to the large difference in density between the heaviest and the lightest material in the compound. Materials of similar density as, for example, varieties of wheat, are comparatively easy to blend because the

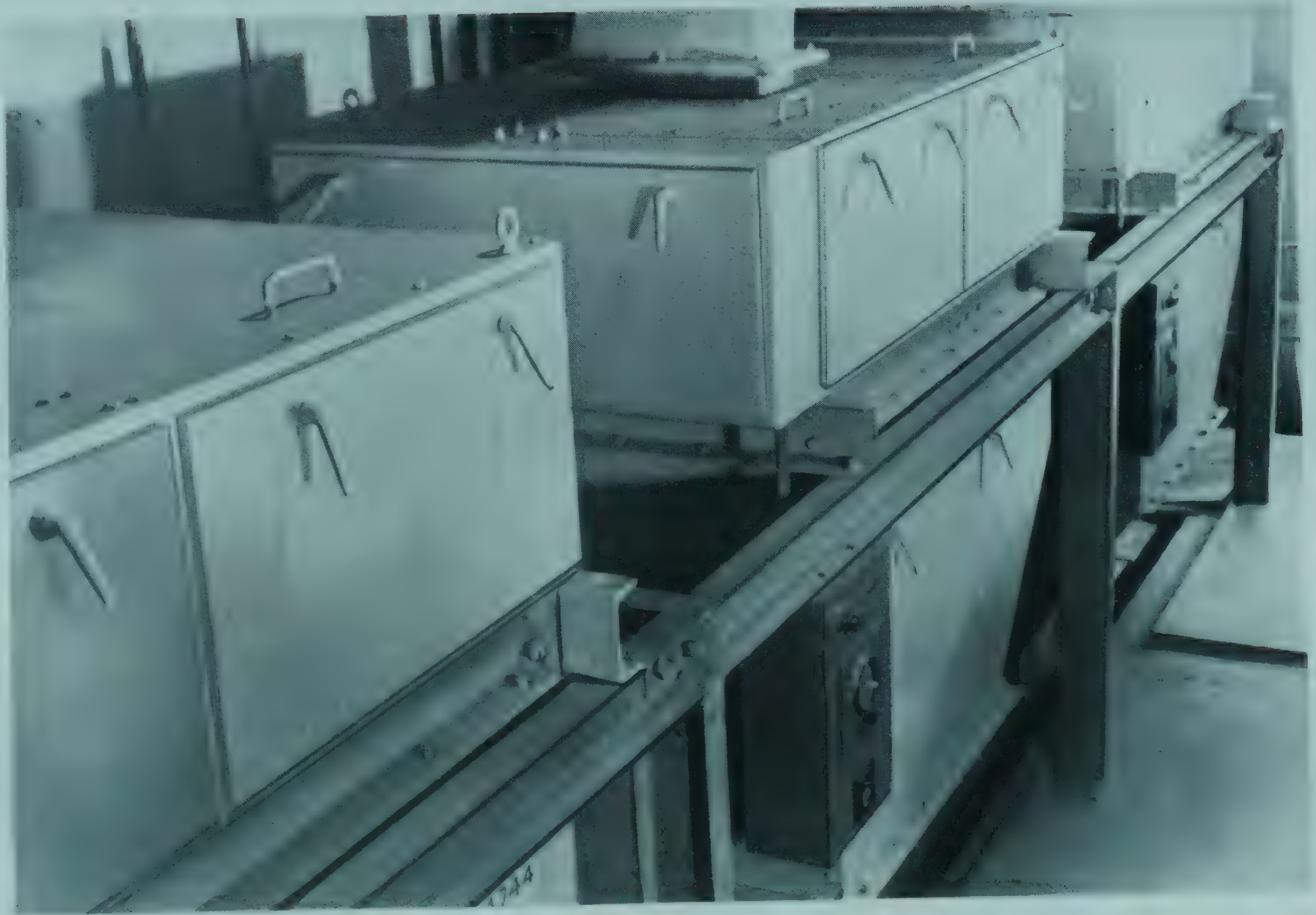


FIG. 134.—Avery fully automatic weighers for continuous blending by weight.

size of a line of weigh buckets may be standardised and made to tip simultaneously by one automatic control, the percentage of each ingredient being adjusted by the weights in the weight box. The density of compound materials, however, varies to such an extent that, if the weighers tipped simultaneously, some would have to be so large that they would be impracticable, particularly those weighing larger percentages of light, bulky materials.

The only alternative methods are, first, to have a number of similar size weighers for each of these large percentage and light ingredients, or second, to make the weigher for each ingredient tip at intervals. The first method involves too many weighers and bins; therefore, the second is more practicable, but as stated above it is used for the large percentage ingredients only, which reduces the number of expensive weighers to about three, the remaining ingredients being handled by hand-operated weighers. In this second system a weigher bucket containing a light material of 15 lb. per cubic ft. tips three times as fast as a bucket with a heavy material of 45 lb. per cubic ft., assuming that their percentage in the ration is the same. If, however, 5 per cent of one and 25 per cent of the other is required, some weigh buckets will have to tip fifteen times more often than others. This involves a system of independent control for each weigher which has to be altered for each formulae or whenever an ingredient is changed.

These electrical systems are similar in principle to those described under volumetric plants, but they are necessarily more elaborate and contain features which are the development of individual millers; they aim at the remote control of each weigher by the manager or foreman who, by changing a chart in his office, can alter the formulae as desired.

In contrast with the volumetric system, batch mixers are necessary in all weigher systems owing to the intermittent blending action of both automatic and hand operated weighers. The weighers deliver to two mixers through conveyors and elevators in the same way as in the semi-continuous batch system. Electrical control systems may be arranged to stop and start the weighers automatically after each mixing is complete, so that the process is continuous.

Fully Automatic Weighers for Continuous Blending by Weight

Automatic weighers under bins are more elaborate than the hand operated type because, in addition to the weighing mechanism itself, they must incorporate mechanism to discharge automatically at intervals the exact quantity of material from the bin necessary to charge the weigh buckets.

Messrs. W. & T. Avery Ltd. manufacture an automatic weigher (Fig. 134) of this type suitable for continuous blending by weight. In Fig. 134, the material is fed to the weigh bucket by an endless chain conveyor which travels through the bottom of the bin and acts as a discharger. The conveyor is driven by a small motor which is controlled by a micro-switch. The weigher works on the beam principle and when the material in the weigh bucket, which holds 200 lb., balances the weights in the weigh box, the beam turns and operates the micro-switch, thus stopping the conveyor and any more material from entering the weigh bucket.

The weigher is discharged in a similar manner by another micro-switch which opens and closes the hopper door of the weigh bucket. This micro-switch is electrically interlocked with that of the conveyor so that the weigh bucket cannot be fed when the hopper door is in the discharge position, and the hopper door cannot be opened until the correct weight of material is in the weigh bucket.

ADVANTAGES AND DISADVANTAGES OF BLENDING BY WEIGHT AND BY VOLUME

In batch plants, the only practical method of blending compounds is by weight; in all others using process bins, the miller must decide whether to blend his ingredients by weight or by volume.

The advantages of any system of blending by weight are :

1. The blend obtained by weighers is more accurate than by volumetric feeders. The rate of passage of a material through a volumetric feeder varies in proportion to its density. Any variation in density of a particular ingredient, if uncorrected, therefore affects the accuracy of the feeders.
2. Saving in production time when changing from one type of ration to another. Feeders have to be reset and checked.
3. Better stock control and assessment of plant efficiency with materials of known weight.

The advantages of any system of blending by volume are :

1. The saving of labour compared with hand operated weighers; labour is only necessary for resetting and checking the feeders at intervals. In the case of weighers, except in the electronic weight control system, one or two men are required for each row of bins according to the type of weigher, layout, and capacity of plant.
2. Continuous feeders, after setting, are controlled automatically and are not subject to the human element. Weigher operators can make mistakes in weighing, except, of course, with automatic weighers.
3. Better discharging owing to material being constantly on the move compared with the intermittent delivery of weighers.
4. No batch mixers are necessary, which simplifies layout, and saves costs compared with automatic and fixed hand operated weighers; where portable weighers are used the cost is approximately the same.
5. Systems consisting entirely of portable hand operated weigh scales are slower to operate than a range of continuous feeders, particularly when the feeders are able to work on one type of ration for long periods.

In summarising the above, it will be seen that, on the whole, weighing systems are designed for those who require very accurate blending and flexibility; they are able to change over quickly from one type of ration to another, and, therefore, are suitable for manufacturing a large variety of mixtures in comparatively small quantities, and for accurately blending a large number of ingredients in small percentages, as in chick rations.

On the other hand, volumetric systems are more labour saving, except for the electronic weight control system, and almost entirely free from mistakes by operators; they are particularly suitable when working for long periods on one type of ration containing fewer and less expensive ingredients, as in the pig ration. There is evidence that the volumetric system, although not so accurate as the weighing system, is sufficiently accurate for animal feeding purposes, particularly when the small percentage ingredients are pre-mixed and efficient feeders are used.

In this country at the time of writing, the Ministry of Agriculture allow a 10 per cent margin of error for the protein figure and 8 per cent for the oil and fibre figures.

For example, if the analysis of a compound ration is

	per cent
Protein	16
Oil	3
Fibre	9

the margin of error allowed in each case will be

	per cent
Protein	17·6 maximum 14·4 minimum
Oil	3·24 maximum 2·76 minimum
Fibre	9·72 maximum 7·28 minimum

Tests taken at regular intervals on volumetric plants in this country have shown that the results are well within this margin, and, in fact, do not vary more than 3 per cent either way from the analysis figures. This gives a safety margin of 7 per cent for protein and 5 per cent for oil and fibre. The volumetric method is, therefore, very popular, particularly where labour costs are high and where the other conditions detailed above apply, as in countries like America and Australia.

At present, therefore, large modern blending and mixing plants having an output of approximately 10 tons per hour upwards are usually based either on the principle of semi-continuous batch weighing using portable or fixed hand operated weighers or the principle of fully automatic, continuous, volumetric blending using feeders; the choice between the two is influenced by a number of local conditions, which vary in different countries and districts, such as the type, number and condition of the raw materials available, the output of the plant, labour and climatic conditions, the type and range of compounds to be made, analysis requirements and so on.

It seems, however, that the ideal to be aimed at in the future is a plant combining both of the foregoing principles, namely fully automatic, continuous weighing. Any plant based on these lines is not only labour saving and foolproof but is accurate in blending as well. The recent development of the electronic weight control system in America, as described in this chapter, is the first step in this direction but, if this type of plant is to be adopted to any great extent, it appears that its high capital cost will have to be reduced.

Chapter XIII

CUBING AND PELLETING MACHINES

All modern cubing and pelleting machines operate on the continuous method which has almost completely superseded the batch method of the early hydraulic presses. There are many types of machines in use but they may be divided into two main classes: one, which had its origin in the earlier machines, works on the moulding principle, and the other, which dates from more recent times, works on the extrusion principle.

MOULDING MACHINES

The operation of moulding or compressing the meal is performed by two large diameter, steel rollers, which have indentations or pockets in their surfaces, and run at equal speeds in opposite directions. Moulding machines, although still used by a few millers, have a relatively small output, high power consumption and lack of flexibility and, therefore, the extrusion type has largely superseded them. The rollers of moulding machines are heavy and difficult to handle so that changing from one size of product to another involves serious loss of production time.

Moulding machines make cakes or nuts of various shapes, such as the triangular, oval, square or button shaped products, but most generally the triangular or diamond shape, usually known as nuggets, and the oval or button shape, known as cakettes, are made. However, with the exception of the few millers referred to, these shapes have been superseded by the cube or cylindrical product made by the extrusion machine, although, apart from the more usual square or round cube or nut, oval and triangular shapes are also sometimes manufactured.

In the moulding principle, the meal is only under pressure for a short time, which is not as suitable for the production of a hard, well polished article as the longer period involved in the extrusion machine. On the other hand, moulding machines are capable of handling a larger quantity of steam and molasses than the extrusion type; this offsets any tendency of the former to produce moulds that crumble due to the shorter compression period.

One advantage of moulding machines is that nuggets or cakettes, produced on any one machine, are of identical size and shape, whereas extruded cubes and pellets tend to vary in length. Also, owing to their shorter compression period, moulding machines are not so liable to have blockages.

The Marshall Machine

The Marshall machine (Fig. 135), made by Rose, Downs & Thompson Ltd., is of the moulding type; it is fitted with a molasses blending kettle, although this is not shown in the photograph. The feed to the moulding section consists of a small hopper pivoted at the back and front so that the

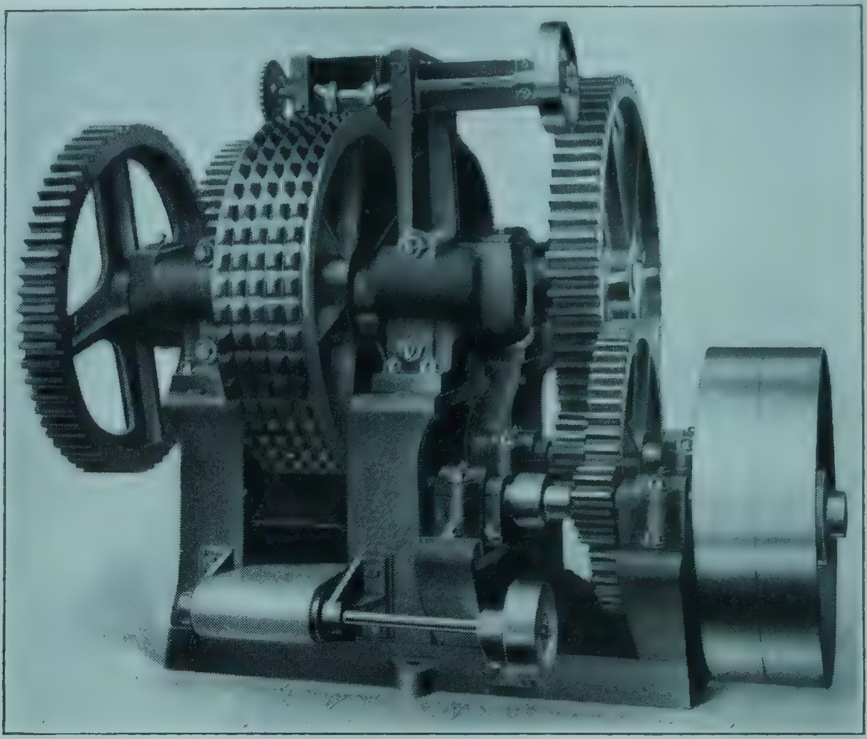


FIG. 135.—Marshall nutting machine.

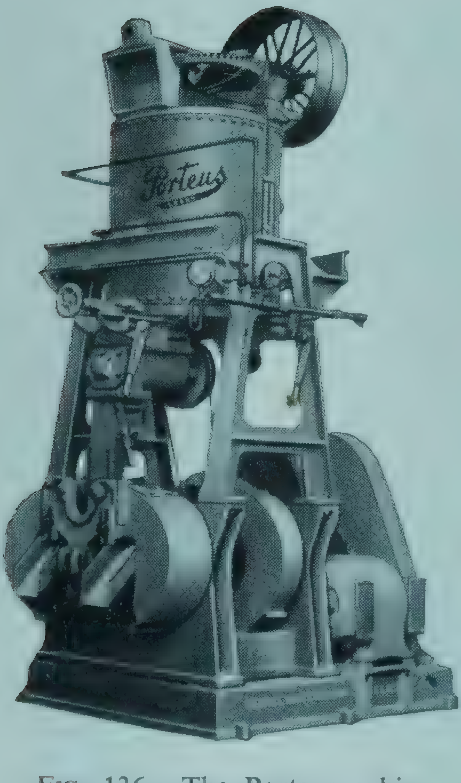


FIG. 136.—The Porteus cubing and pelleting machine.

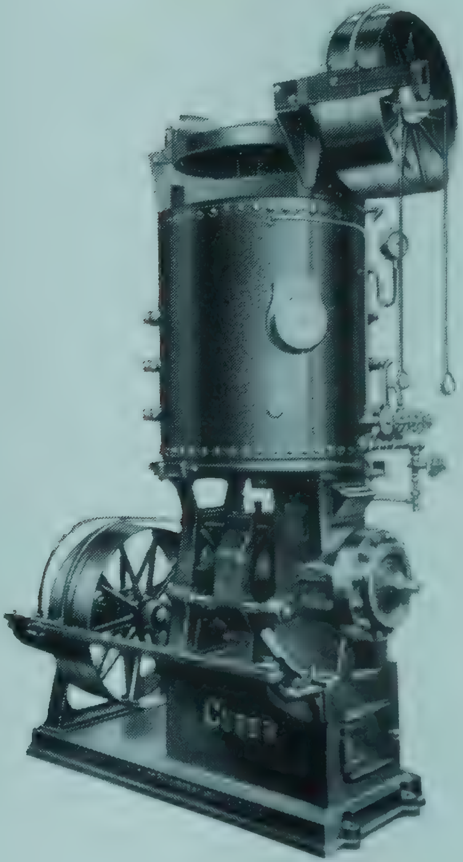


FIG. 137.—Cuber.

bottom is moved in and out by two small cranks, thereby giving the meal a slight preliminary compression.

The meal then falls between two steel rollers revolving at approximately 7 r.p.m. in opposite directions; they are driven by spur reduction gears and fast and loose pulleys. The meal is moulded into the shape required by the complete closure under pressure of the indentations or pockets in the surfaces of the rollers. The rollers are replaceable, so that different shapes and sizes of nuggets and cakettes may be made as required, and they are kept clean and free of caked meal by scrapers immediately after the discharge point.

A short band conveyor, running beneath the rollers, delivers the product clear of the machine. Nuggets or cakettes usually leave the machine joined together by a thin layer of meal formed by compression of the two surfaces of the rollers between the spaces or lands of the indentations. This slab formation is broken up by the teeth of a simple rake, which is placed in the path of the slab as it leaves the band conveyor, and ensures that the nuggets are delivered as separate pieces.

EXTRUSION MACHINES

Machines employing the extrusion method may be divided into two sections (*a*) and (*b*).

Section (*a*)

This type, known as the *Scheuler* type from the name of the inventor, embodies two spur toothed gear wheels, which run in opposite directions, each having holes in their rims at the root of the teeth. The compressed meal is extruded through the holes in two streams and cut off as cubes or pellets by stationary knives placed on the inside of each wheel.

1. The Porteous Machine

An example of the *Scheuler* type is the machine made by George Porteus (Leeds) Ltd. (Fig. 136). It is fitted with a steam-jacketed kettle which heats the meal and mixes the molasses by means of a number of fixed and rotating stirrer arms.

The molassed meal is discharged through a short worm conveyor into the nip of two spur-toothed gear wheels, revolving in opposite directions, provided with holes in their rims as described above. This method produces two separate streams of cubes or pellets, which are cut off by the stationary knives placed inside each wheel, and flow down the twin discharge chute. The gear wheels are mounted outside the main frame and may be easily changed. A variable speed motor for cubes and pellets is fitted. Two sizes of machine are made, the smaller size being fitted with a 30/40 h.p. motor for cubes or pellets and the larger with a 40/50 h.p. motor.

Section (*b*)

The second section embodies a number of machines employing variations of the same principle as follows:

1. Machines employing stationary, vertical or horizontal flat dies having holes in their faces, through which the meal is extruded under pressure

by compression worms or revolving rollers, the compressed meal being cut off as cubes or pellets by revolving knives. Examples are the Sizer 'Cuber', the Templewood and the Simon 'Heavy duty' Californian Press.

2. Machines employing revolving, horizontal flat dies and stationary knives. Examples are the Sizer 'Pelcub' and 'Pelcub Major' machines.
3. Machines employing revolving, horizontal or vertical ring dies, revolving rollers and stationary knives. Examples are the 'Sizer', the Sizer 'Orbit' range and the Simon 'Master Model' and 'Century' Californian Presses.

1. The Cuber

The Cuber (Fig. 137) is made by Richard Sizer Ltd. The meal is heated in a steam-jacketed kettle containing stirrer arms driven through bevel gears. External live steam jets are fitted in the sides of the kettle together with a mushroom on the bottom and steam to the jacket. Molasses is added and blended in the kettle, which is also fitted with a meal temperature recorder, a meal level indicator and a control switch.

The molassed meal is discharged through a hand controlled slide into a cylinder in which a compression worm forces .the meal through a fixed, vertical die plate. A knife, fitted to the compression worm shaft, revolves over the outer face of the die and cuts the compressed material to the required length. A single bladed knife is used for cubes and a special five finger bladed knife, which enables shorter lengths to be cut, is used for pellets.

The cubing and pelleting sections of the machine and the kettle are both driven by fast and loose pulleys, but in some machines the former may be driven by vee ropes. The Cuber is flexible for the manufacture of either cubes or pellets because the die can easily be changed in about 10 minutes, and the machine will make large cubes up to 2 in. square.

2. The Templewood

This machine, as illustrated in Chapter XVI, is manufactured by the Templewood Engineering Co. Ltd., and is mainly intended for grass cubing but also cubes compounds. As in the *Sizer*, it uses water only and has a capacity of 12 cwt. per hour of $\frac{7}{16}$ in. cubes with grass meal based on 24 lb. per cubic ft.

The machine is fitted with a feed hopper containing an agitator, the feed to the mixing chamber being controlled by a ratchet feeder worm which is adjusted by a calibrated lever on the side of the machine. A water tank is fitted above the machine so that water flows by gravity through a calibrated flow meter into the mixing chamber where it is mixed with the meal.

The damped meal then passes to the vertical cubing chamber; further stirring takes place and the meal is pressed downwards by a slight screw action into two annular crescent-shaped spaces between the stationary horizontal ring die with holes arranged radially, and the revolving adjustable roller cams. The cubes are cut off by an adjustable revolving knife.

The machine is driven by a 20 h.p. motor through vee belts to the main horizontal shaft running at approximately 450 r.p.m., which drives the vertical roller camshaft through bevel gears in an oil bath. A smaller set of bevel gears drives the hopper agitator and feeder.

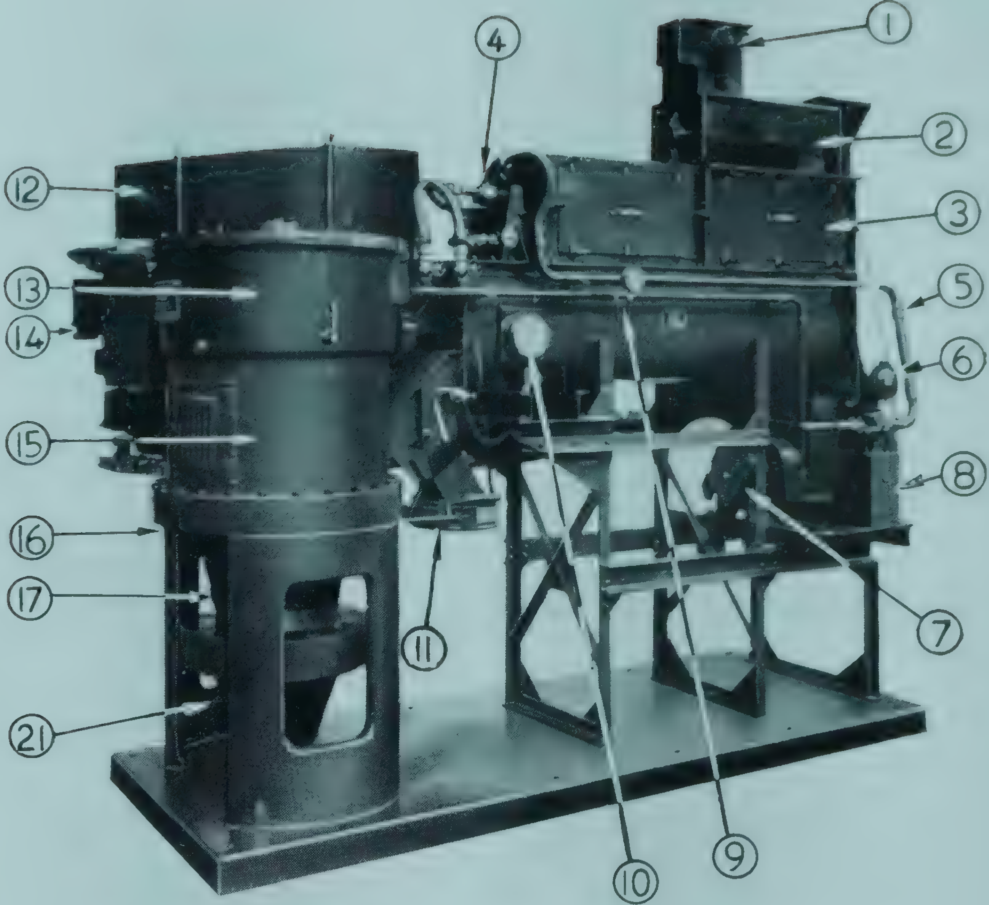


FIG. 138A.—The Simon Californian press (heavy duty type).

1. Spout flow indicator. 2. Ratchet feed worm. 3. Cascade molasses mixing worm. 4. Atomiser. 5. Molasses pipe line. 6. Molasses meter. 7. Molasses regulator. 8. Stop and start device. 9. Steam pressure gauge. 10. Meal temperature recorder. 11. Molasses meals discharge. 12. Vee rope drive. 13. Gear case. 14. Motor. 15. Roller assembly. 16. Horizontal stationary die. 17. Knife bracket assembly. 18. Knives. 19. Rolls. 20. Steel spider. 21. Cube and pellet discharge.

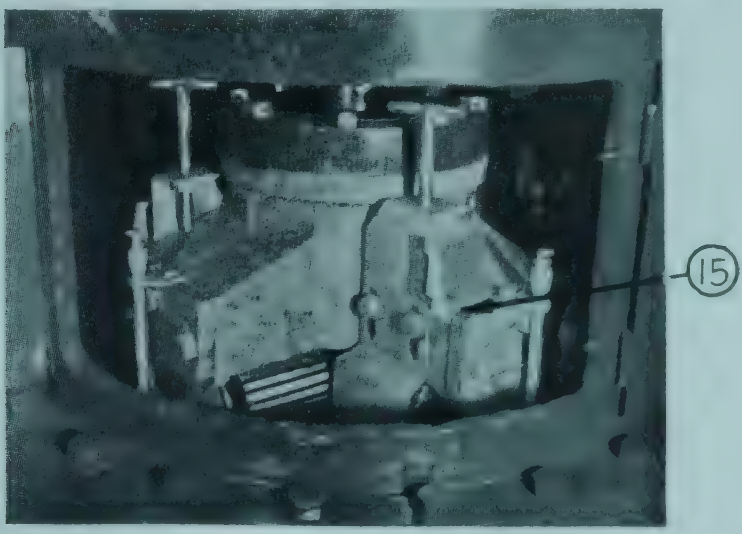


FIG. 138B.—Interior of roller assembly—Simon Californian press (heavy duty type).

3. The Californian Press (Heavy Duty Type)

This machine (Figs. 138A, B and C) is made by Henry Simon Ltd., and is constructed in two sections supported on a single base plate by vertical cast iron stands.

Section one consists of the Cascade Molasses Mixer and the Automatic Molassing Assembly for the manufacture of molassed compound meals. The section may be supplied as an independent machine, as described under Continuous Mixers, but, when it forms part of the Heavy Duty Californian Press, it is driven through a chain and sprocket by a 3 h.p. geared motor supported on a stand.

Section two is the cubing and pelleting part of the machine and consists of the cast iron bowl supported on stands into which the molassed meal is discharged by a chute from the Cascade Molasses Mixer. On this bowl is carried a gear box containing an arrangement of spur reduction gears for driving the main vertical shaft by means of a vee rope drive. The vertical shaft carries a cast steel spider on which are mounted four hardened steel rollers, each mounted on roller bearings and arranged radially on horizontal spindles.

Power is supplied by a 40 h.p. side-mounted motor and vee rope drive. The drives are arranged independently so that, if desired, molassed compound meals may be manufactured by running the 3 h.p. mixer motor only; the meals may be packed off by turning a valve to a catch off spout before entering the cubing and pelleting section.

The rollers (Fig. 138B) rotate over a stationary circular die plate carried from the underside of the bowl by a steel ring which is made in two halves for easy removal. This action forces the meal through the holes in the die plate and the compressed meal, on emerging from the underside of the die, is cut off into the required lengths by revolving knives, which revolve with the roller shaft, thus producing cubes or pellets.

The lower end of the knife shaft carries a square to which is fitted a cast iron bracket with four removable arms. Each arm holds a fixed spindle carrying a circular steel knife which is free to rotate on its own spindle. Although the knife bracket revolves, the movement of each knife on its fixed spindle prevents the wear of the cutting edge always being in the same place.

Each spindle is easily adjustable vertically to enable the knives to be set at a suitable distance from the under surface of the die. A conical bush is arranged in the centre of the knife bracket which enables the knives to be set in the correct relation to the rollers; the centre of each knife spindle should be midway between two rollers. The number of knives determine the length of the cubes or pellets. In most conditions, four knives are used for the smallest $\frac{3}{32}$ in. chick pellets and one knife for the largest $\frac{3}{4}$ in. cubes. Two knives are used for intermediate sizes, but three knives should never be used because this will result in cubes of irregular length.

The cubes and pellets are collected from the underside of the die by a hopper which discharges through a central hole in the base plate to the centre of the cooler.

The die can be easily changed in 30 minutes, thus making the machine flexible for the manufacture of all sizes of cubes and pellets.

To change the die, it is necessary to remove the discharge hopper and the knife bracket, loosen the thrust nut and remove the split ring under the die. The die jack is then inserted to take the weight of the die while the die clamps, which are in two halves, are removed. The die is then lowered on the jack and the process is repeated in reverse order.

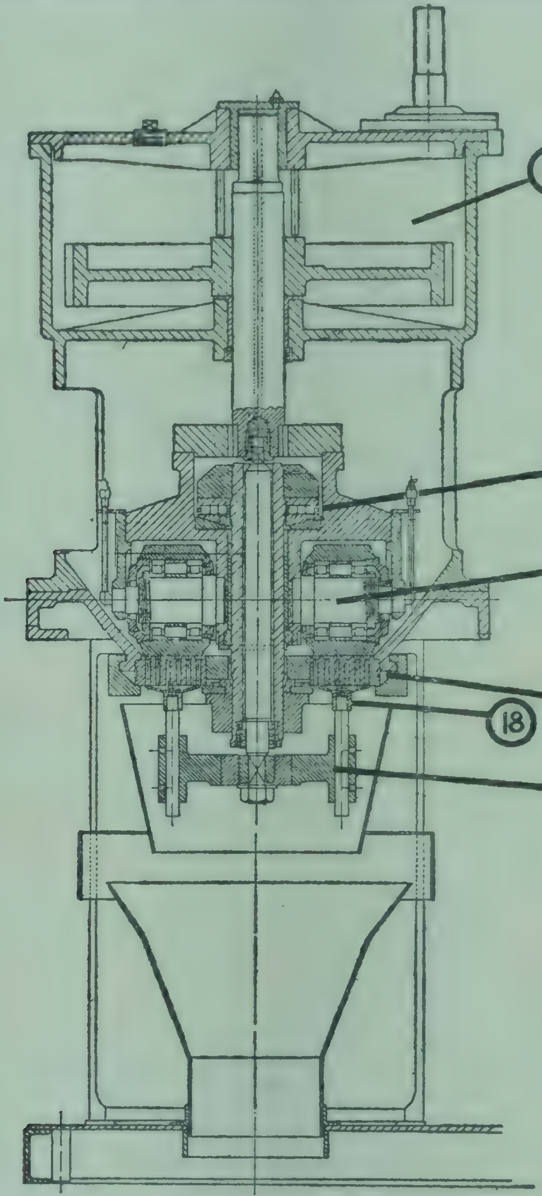


FIG. 138C.—The Simon Californian press (heavy duty type). (*See Fig.* 138A *for key to numbers.*)

4. THE PELCUB AND PELCUB MAJOR MACHINES

In the Pelcub machines, made by Richard Sizer Ltd. (Fig. 139), the die revolves in one direction while the head carrying the rollers revolves in the opposite direction. The rollers are mounted on ball bearings and rotate on their axis as they are driven round by the double bevel gear drive at the bottom of the machine.

For heating the meal and mixing the molasses, the machine is fitted with a steam-jacketed kettle similar in design to the other Sizer machines and

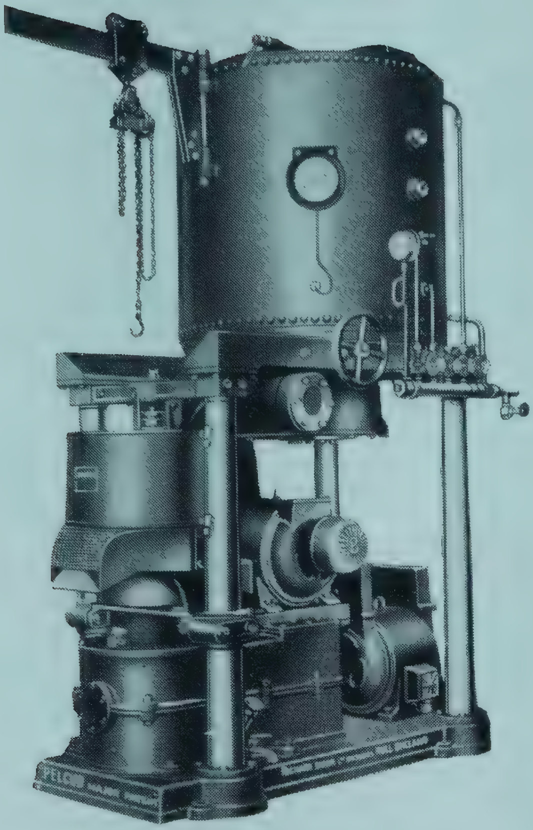


FIG. 139.—The Sizer Pelcub Major.

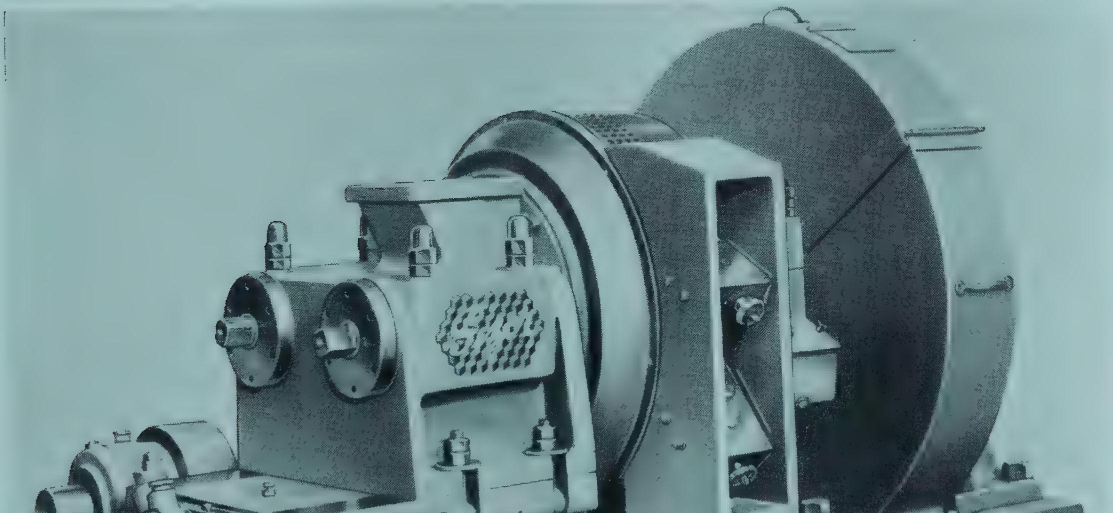

ORBIT
RICHARD SIZER LTD
ENGINEERS HULL

FIG. 140.—The Sizer 10-ton 'Orbit'.

driven by a separate motor by means of a Renold chain and worm reduction gear.

The molasses meal is discharged from the kettle through a slide and chute into the feeding bowl. At the bottom of the bowl is a revolving plate having four adjustable circular holes through which the meal is evenly distributed in front of four steel compression rollers revolving with the vertical shaft. The meal is assisted into the path of the rollers by four ploughs. The die plate revolves in the opposite direction to the rollers, the extruded meal being cut off to the desired length by stationary knives placed underneath the die. The number of knives used determines the length of the cubes or pellets which are discharged at the side of the machine.

The die and roller assembly are revolved in opposite directions by spur and bevel gears or vee ropes. The gears are enclosed in a gear box situated beneath the die. The Pelcub machine has a 30 h.p. motor mounted on the bedplate driving through vee ropes and chains, and the Pelcub Major has a 45 h.p. motor mounted on the bedplate and direct coupled to the gear box. A jib crane is provided with the machine to assist the changing of dies, which are lifted out at the top of the machine over the main shaft after the feeding bowl and compression rollers have been removed.

THE 'ALL IN ONE' UNIT

The Pelcub machine is also put up in 'All in One' unit form, so that all the ancillary plant is incorporated in the one frame.

In this unit, the various ingredients are fed into an elevator discharging to a vertical mixer. When each batch is mixed, the meal passes over a screen to take out any foreign matter in the meal and it is then fed into the same elevator and discharged into the bin before the Pelcub.

The meal is fed automatically from the bin over a magnet into the cooking kettle of the cubing machine. While the Pelcub is being fed from the bin in a continuous flow, another batch of meal is being mixed and, after screening, is deposited into the bin so that there is a supply of meal for the cubing machine.

Steam is injected into the meal in the kettle either by means of the mushroom at the bottom or by branches fitted into the side. The kettle body is also steam heated by means of its jacket. Molasses is added into the meal in the kettle from the heating tank above the unit. The percentage of molasses is regulated by means of change gears on the molasses pump and the level of meal in the kettle is kept constant through an automatic switch which electrically controls the feed from the bin. When the worm at the bottom of the bin has fed enough meal into the kettle, an automatic switch stops the motor driving the worm and, when the level in the kettle falls, the automatic switch comes into operation and restarts the worm.

After cubing, the cubes or pellets are elevated to the cooler. The cooler is discharged by a shoe feeder and the cubes are again elevated over a screen into a bagging-off hopper fitted either with two spouts for continuous bagging-off, or with an automatic weighing machine. The level of cubes in the cooler is controlled by an electrical switch which operates the discharge shoe feeder on the same principle as described for the kettle. This ensures even cooling as detailed in the chapter dealing with cooling.

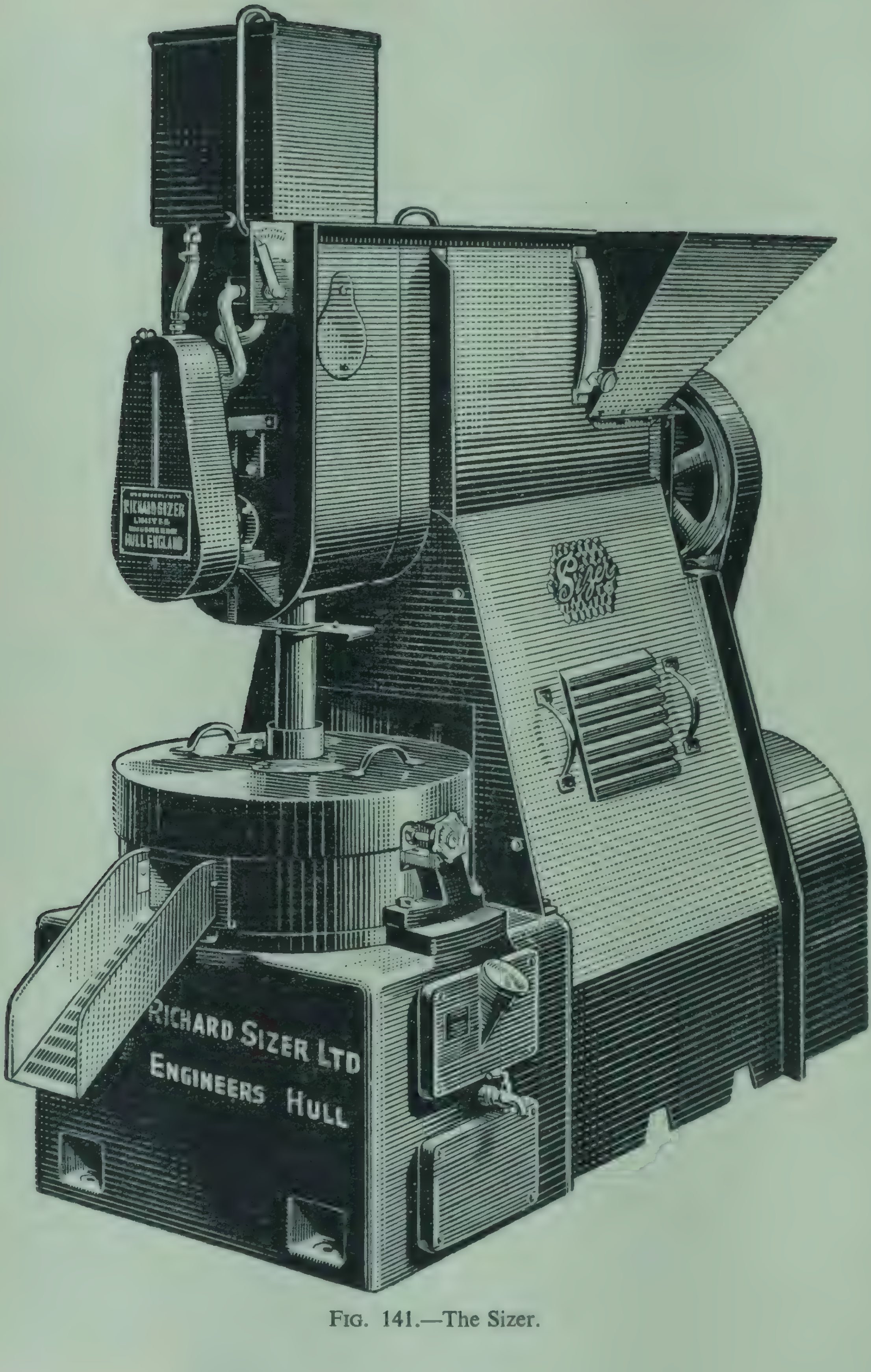

RICHARD SIZER
LIMITED
ENGINEERS
HULL ENGLAND
Sizer
RICHARD SIZER LTD
ENGINEERS HULL

FIG. 141.—The Sizer.

There is a platform at the top of the plant which is accessible by a steel ladder for inspection purposes. To facilitate die changing, a jib is provided with a runway, and chain blocks are used for lifting and replacing the bowl and the die. The space occupied by the plant is 24 ft. 8 in. × 12 ft. × 16 ft. 6 in. high.

5. The Sizer

This machine (Fig. 141) is one of the more recent to be developed by Richard Sizer Ltd. Although originally intended for cubing grass meal at the rate of approximately 5 cwt. per hour of ½ in. cubes according to the type of meal, it also manufactures about 18 cwt. per hour of ½ in. compound cubes. The machine incorporates a Turbulator consisting of a ratchet feeder, mixing worm and chamber and a water-adding unit which works in conjunction with the feeder, no steam being used. The cubing section has a revolving horizontal ring die with two rollers running inside it and mounted on a bridge across the die.

This machine is also used in 'All in One' units as described in Chapter XVI.

6. The Orbit

This is another machine (Fig. 142) made by Richard Sizer Ltd. for the manufacture of cubes only. The kettle for heating the meal and blending the molasses is similar to the Cuber and Pelcub kettles already described.

A hand-controlled slide discharges the molassed meal from the kettle through a worm feeder into the cubing section. This consists of a slowly revolving ring die with holes, arranged radially, through which the meal is forced by a revolving steel compression roller running in contact with the internal face of the die. The roller and the die are each mounted on independent driving shafts geared to a common countershaft so that the surface speeds of the roller and die at the point of contact are equal. This action compresses the meal entering at the side of the die between the two conveying arcs, a gradually increasing pressure being applied. The ring die revolves four times while the meal is being forced through the holes and this time factor compresses the cubes very firmly and gives them a high polish.

The extruded meal is cut off into cubes by a stationary knife on the external face of the revolving die. This cutting principle ensures that the cubes are of uniform length. Two knives are mounted side by side on a slide so that when one becomes blunt it can be removed for re-sharpening and the other can be put into action without stopping the machine.

To change the die, the pedestals carrying the die shaft bearings and the shaft may be removed by a screwed spindle until the die is clear of the roller. The bolts which hold the die to a flange on the shaft may then be removed and the die can be lifted clear of the machine. Roller bearings are fitted throughout and the machine can be driven either by fast and loose pulleys or by a direct coupled 35 h.p. motor.

7. The 10-ton Orbit

This machine (Fig. 140) is a modification of the foregoing; it has an output of 9 tons per hour of ⅝ in. cubes compared with 3-4 tons per hour for the original Orbit, and it will also produce 5 tons per hour of $\frac{3}{16}$ in.

pellets. The kettle is of the standard type, slightly modified to suit the higher output, and is driven by a 25 h.p. motor through a worm reduction gear mounted underneath the kettle.

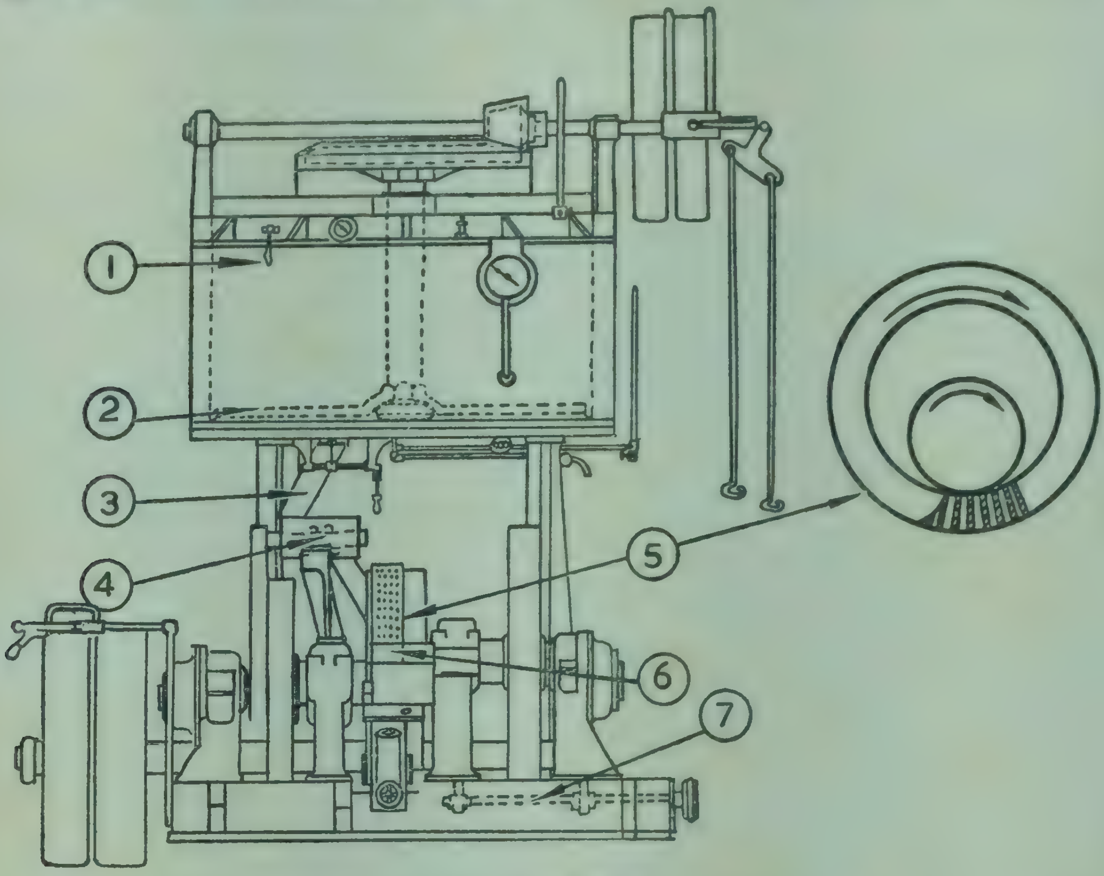


FIG. 142.—The Sizer ' Orbit '.

1. Kettle. 2. Stirrers. 3. Feed spout. 4. Worm feeder. 5. Ring die. 6. Independent driving shafts for roller and die geared to common driving shaft. 7. Screwed spindle for removing pedestals when changing die.

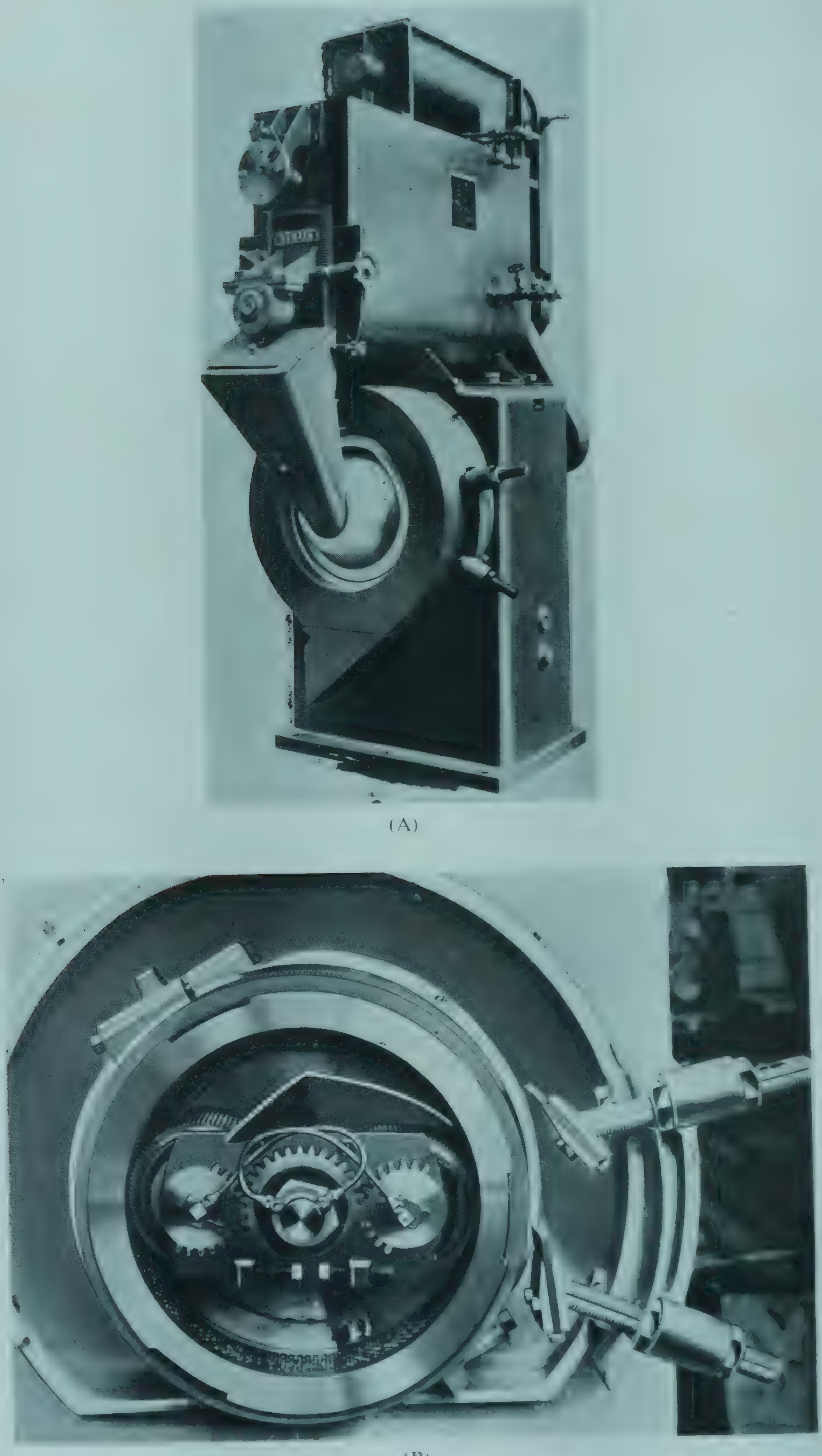
The machine itself is driven through a chain by a 70 h.p. motor and incorporates two rollers, one on each side of the ring die, instead of one as in the foregoing type. The original Orbit machine may be modified to suit the higher output.

8. THE MASTER MODEL CALIFORNIAN PRESS

The Master Model Californian press (Figs. 143A, B and C) is made by Henry Simon Ltd., and consists of a ratchet feeder worm, a molasses mixing and steaming section and a cubing and pelleting section. The machine is driven by a 30 h.p. motor and vee belt drive through a series of gears in a self-contained gear box.

The ratchet feeder worm is driven from the mixing worm shaft by chain and sprocket drive. The feeder control mechanism is entirely enclosed and is provided with sixty positions to give different variations of feed to the machine. The feed required can be selected by moving the indicating arm whilst the machine is running.

The Molasses Mixing and Steaming Section is designed for adding molasses and steam to the meal and is similar to the independent cascade



(A)

(B)

Fig. 143.—The Simon Master model Californian press.

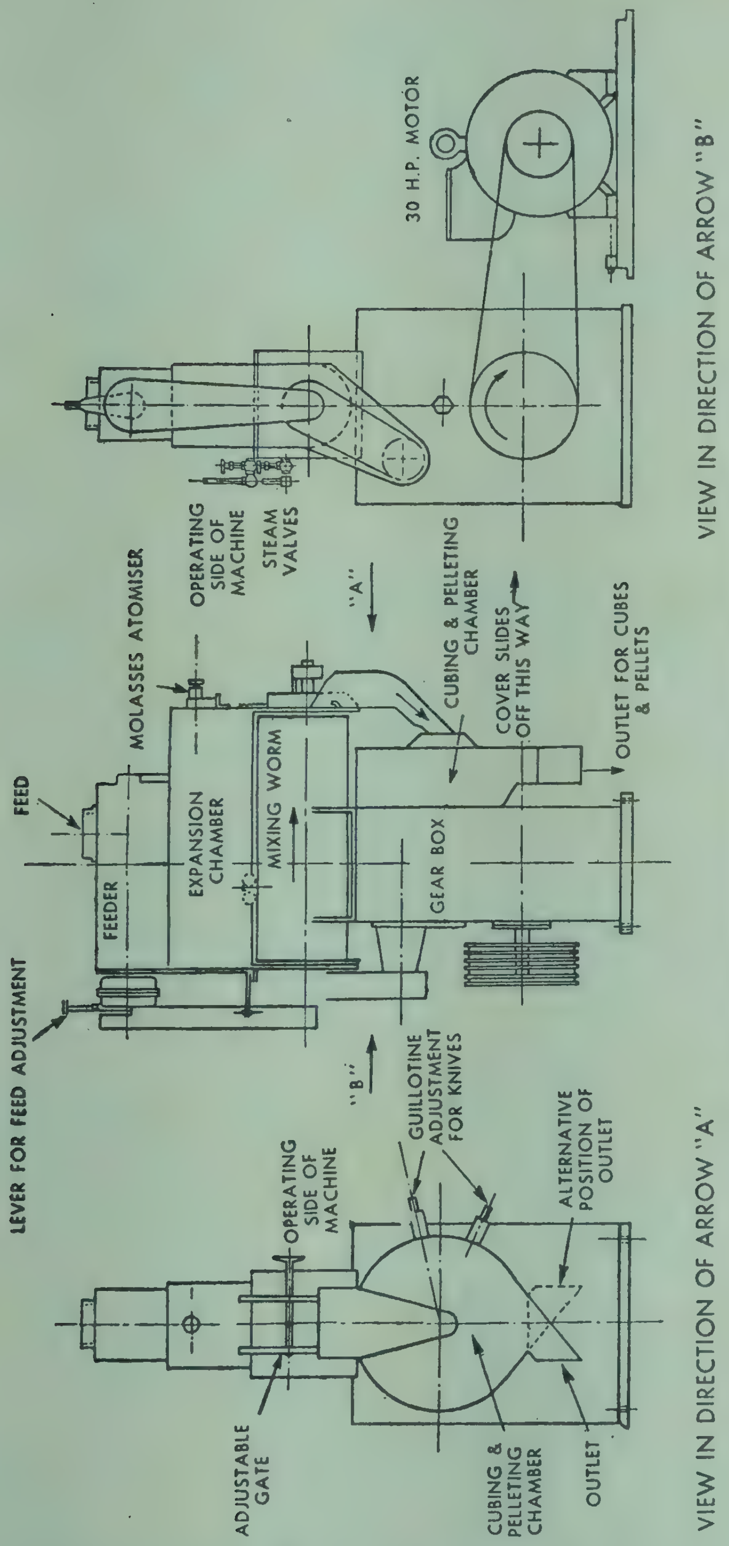

30 H.P. MOTOR
VIEW IN DIRECTION OF ARROW "B"
OPERATING SIDE OF MACHINE
STEAM VALVES
MOLASSES ATOMISER
"A"
CUBING & PELLETING CHAMBER
COVER SLIDES OFF THIS WAY
OUTLET FOR CUBES & PELLETS
FEED
EXPANSION CHAMBER
MIXING WORM
GEAR BOX
FEEDER
LEVER FOR FEED ADJUSTMENT
"B"
GUILLOTINE ADJUSTMENT FOR KNIVES
OPERATING SIDE OF MACHINE
ALTERNATIVE POSITION OF OUTLET
ADJUSTABLE GATE
CUBING & PELLETING CHAMBER
OUTLET
VIEW IN DIRECTION OF ARROW "A"

FIG. 143C.—The Simon Master Model Californian press.

mixer and mixing unit of the *Heavy Duty Californian press*, but on a smaller scale. It consists of a worm with specially designed blades and an expansion chamber fitted with an atomiser at the front of the machine. The worm cascades the meal into the expansion chamber, the molasses being atomised into the meal in a fine mist in conjunction with the steam. This action minimises the ' balling ' of the molasses and reduces power consumption. Independent steam may also be added in the side of the mixing unit.

The molasses is regulated by a valve before the atomiser after it has flowed by gravity through a strainer from the steam heated service tank situated above the machine.

The molassed meal enters the cubing and pelleting section from the mixing section via an adjustable discharge gate and a feed chute. The cubing and pelleting section consists of a ring or annular die, which revolves with the feed cone in a clockwise direction, and which, in turn, revolves two hardened steel rollers through their contact with the inner surface of the die. The meal, which is fed into the centre of the feed cone, is carried into the path of the left-hand roller by the speed of the die and is also deflected into the path of the right-hand roller by a guide plate. The meal is forced through the die holes by the rollers and, on emerging on the outside of the die, is cut off into cubes or pellets according to the length required, by one or two stationary knives.

The rollers run on roller bearings on stationary hubs which are mounted on eccentrics. The correct adjustment of the rollers to the face of the die is important and simple mechanism is provided for this purpose. Economy will result if a set of dies and rolls is kept for each size of cube or pellet. Worn rolls should not be fitted with a new die or vice versa. The rollers, which should be just revolving when there is no feed on the machine, are lubricated through pipes from the main gear box.

A feature of the Master Model is the sheer pin assembly which is designed to protect the die and rollers from damage by foreign material. On entering most extrusion machines, hard material is liable to be forced into or through the die and rollers, thus causing serious damage. In the Master Model, the shear pin breaks under increased strain and permits the mainshaft flange to rotate so that the die and rollers are free to revolve together without forcing the foreign material into the die.

The Master Model Californian press is designed for installation either as a single unit by a small miller, or in batteries by a large miller. It is suitable for a mixed trade of cubes and pellets owing to the quick method of changing the die which takes approximately 10 minutes. It also has a particularly high capacity on pellets in relation to its initial cost.

In changing the die, it is only necessary to relieve the pressure of the rollers and knives on the die and to take off the feed spout, the die cover, the feed cone and the split ring which clamps the die in position. The die cover or pellet chamber slides off after the removal of two thumb screws and the feed cone is easily detached from the die.

9. THE CENTURY MODEL CALIFORNIAN PRESS

This machine (Figs. 144A, B and C) is another of the Californian press group to be made by Henry Simon Ltd. The cubing section of the machine is similar in design to that of the Master Model except that it is larger, more robust and has over double the capacity of the latter on both cubes and pellets. The standard machine is driven by a 50 h.p. motor but, if higher output is required, larger motors may be fitted. A feature of the Century is that when the shear pin breaks it cuts out the motor.

CUBING AND PELLETING MACHINES

CAPACITIES AND HORSE POWERS OF CUBING AND PELLETING MACHINES

<table>
<tr><th rowspan="2"><i>Machine</i></th><th colspan="2"><i>Total h.p.</i></th><th colspan="3"><i>Capacities (tons per hour)</i></th><th rowspan="2"><i>Remarks</i></th></tr>
<tr><th><i>Cubes</i></th><th><i>Pellets</i></th><th>⅝ <i>in. Cubes</i></th><th>½ <i>in. Cubes</i></th><th>$\frac{3}{16}$ <i>in. Pellets</i></th></tr>
<tr><td>Porteus No. 1</td><td></td><td></td><td></td><td></td><td></td><td>Variable speed motor for cubes and pellets.</td></tr>
<tr><td>Kettle</td><td>10</td><td>10</td><td></td><td></td><td></td><td></td></tr>
<tr><td>Machine</td><td>20</td><td>30</td><td></td><td></td><td></td><td></td></tr>
<tr><td>Total</td><td>30</td><td>40</td><td>2</td><td>2</td><td>¾</td><td></td></tr>
<tr><td>Porteus No. 2</td><td></td><td></td><td></td><td></td><td></td><td>Variable speed motor for cubes and pellets.</td></tr>
<tr><td>Kettle</td><td>10</td><td>10</td><td></td><td></td><td></td><td></td></tr>
<tr><td>Machine</td><td>30</td><td>40</td><td></td><td></td><td></td><td></td></tr>
<tr><td>Total</td><td>40</td><td>50</td><td>3</td><td>3</td><td>1¼</td><td></td></tr>
<tr><td>Cuber</td><td colspan="2">20</td><td>2</td><td>1½-2</td><td>1-1¼</td><td></td></tr>
<tr><td>Templewood</td><td colspan="2">20</td><td>¾</td><td>¾</td><td></td><td>12 cwt. $\frac{7}{16}$ in. grass cubes based on meal at 24 lb. cu. ft. and 9 cwt. of $\frac{7}{32}$ in. pellets.</td></tr>
<tr><td>Californian Press Heavy Duty Type</td><td colspan="2"></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Mixer</td><td colspan="2">3</td><td></td><td></td><td></td><td></td></tr>
<tr><td>Machine</td><td colspan="2">40</td><td></td><td></td><td></td><td></td></tr>
<tr><td>Total</td><td colspan="2">43</td><td>4-4½</td><td>3-3½</td><td>1½-2</td><td></td></tr>
<tr><td>Pelcub</td><td colspan="2"></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Kettle</td><td colspan="2">10</td><td></td><td></td><td></td><td></td></tr>
<tr><td>Machine</td><td colspan="2">30</td><td></td><td></td><td></td><td></td></tr>
<tr><td>Total</td><td colspan="2">40</td><td>2½</td><td>2</td><td>1½-1¾</td><td></td></tr>
<tr><td>Pelcub Major</td><td colspan="2"></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Kettle</td><td colspan="2">20</td><td></td><td></td><td></td><td></td></tr>
<tr><td>Machine</td><td colspan="2">45</td><td></td><td></td><td></td><td></td></tr>
<tr><td>Total</td><td colspan="2">65</td><td>4½-5</td><td>4</td><td>2½</td><td></td></tr>
<tr><td>Sizer</td><td colspan="2">15</td><td>1</td><td>1¾</td><td>¾</td><td>¼ ton on ½ in. grass cubes.</td></tr>
<tr><td>Orbit</td><td colspan="2"></td><td></td><td></td><td></td><td>This machine does not make pellets.</td></tr>
<tr><td>Kettle</td><td colspan="2">10</td><td></td><td></td><td></td><td></td></tr>
<tr><td>Machine</td><td colspan="2">35</td><td></td><td></td><td></td><td></td></tr>
<tr><td>Total</td><td colspan="2">45</td><td>4</td><td>3-3½</td><td>—</td><td></td></tr>
<tr><td>10-Ton Orbit</td><td colspan="2"></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Kettle</td><td colspan="2">25</td><td></td><td></td><td></td><td></td></tr>
<tr><td>Machine</td><td colspan="2">70</td><td></td><td></td><td></td><td></td></tr>
<tr><td>Total</td><td colspan="2">95</td><td>9</td><td>8</td><td>5</td><td></td></tr>
<tr><td>Master Model Californian Press</td><td colspan="2">30</td><td>2-2½</td><td>2</td><td>1½</td><td></td></tr>
<tr><td>Century Model Californian Press</td><td colspan="2"></td><td></td><td></td><td></td><td>Larger motors may be fitted with resulting increase in capacity.</td></tr>
<tr><td>Mixer</td><td colspan="2">3</td><td></td><td></td><td></td><td></td></tr>
<tr><td>Machine</td><td colspan="2">50</td><td></td><td></td><td></td><td></td></tr>
<tr><td>Total</td><td colspan="2">53</td><td>5-5½</td><td>5</td><td>3-3½</td><td></td></tr>
</table>

Note.—H.p. figures refer to motors supplied with machines, the actual power consumption is less. Capacity figures are based on compound meal having density of approximately 30 lb. per cu. ft. except where otherwise stated.

The mixing section of the Century Model is arranged differently to the Master Model, and is driven independently of the cubing section by a geared motor and vee rope drive. This arrangement gives more adaptability of layout, enabling the cubing section to be used as a separate unit or in conjunction with any kind of molasses mixer or kettle, as described under Continuous Mixers.

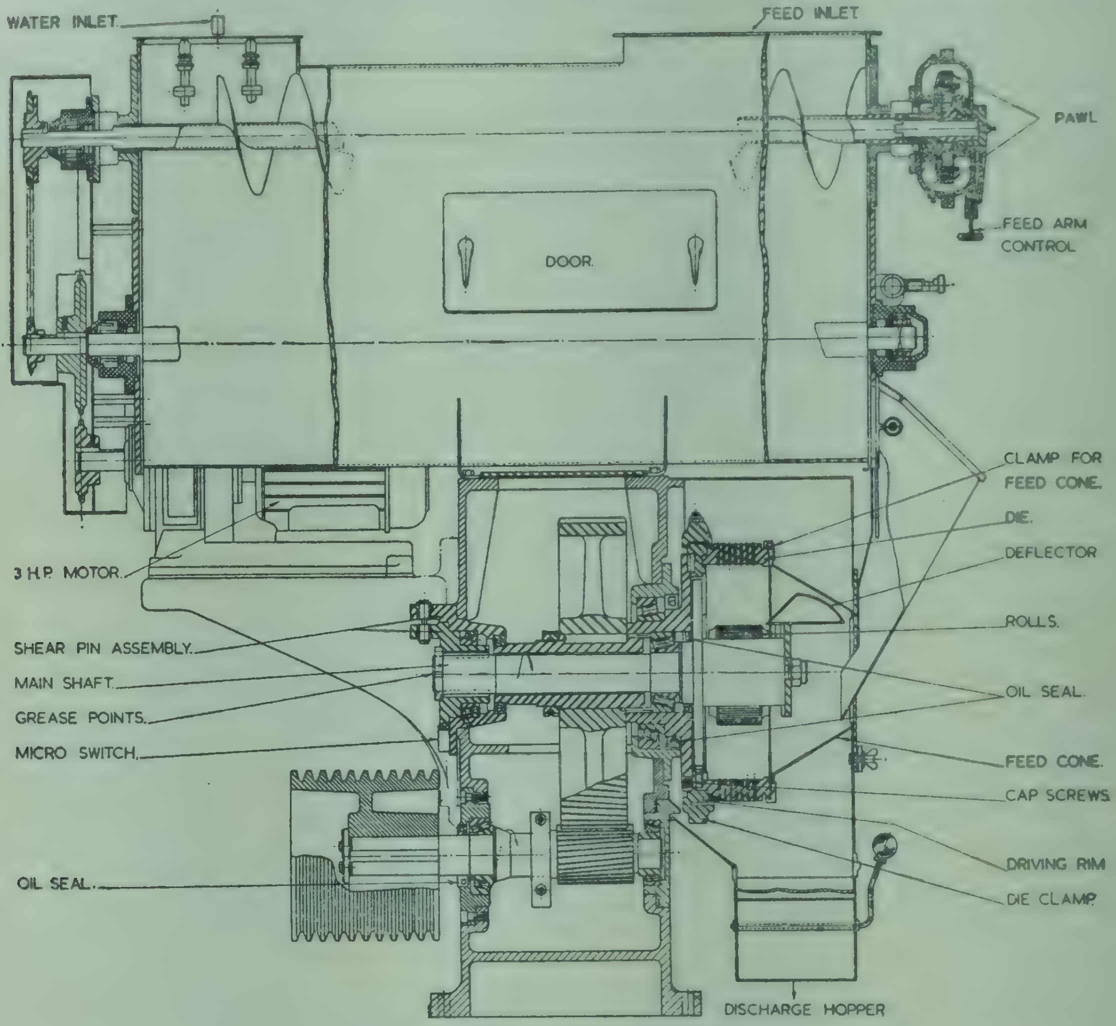

WATER INLET
FEED INLET
PAWL
FEED ARM CONTROL
DOOR
CLAMP FOR FEED CONE
DIE
DEFLECTOR
3 H.P. MOTOR
ROLLS
SHEAR PIN ASSEMBLY
MAIN SHAFT
OIL SEAL
GREASE POINTS
MICRO SWITCH
FEED CONE
CAP SCREWS
OIL SEAL
DRIVING RIM
DIE CLAMP
DISCHARGE HOPPER

Fig. 144A.—Simon Century model Californian Press.

Unlike the Master Model, the Century ratchet feeder worm and mechanism is situated on the same side as the die, thus allowing for easier operation; in each machine live steam and water jets are fitted to the mixing section. In the Century an inspection or exhaust opening is provided at the top of the mixing section opposite the feed inlet.

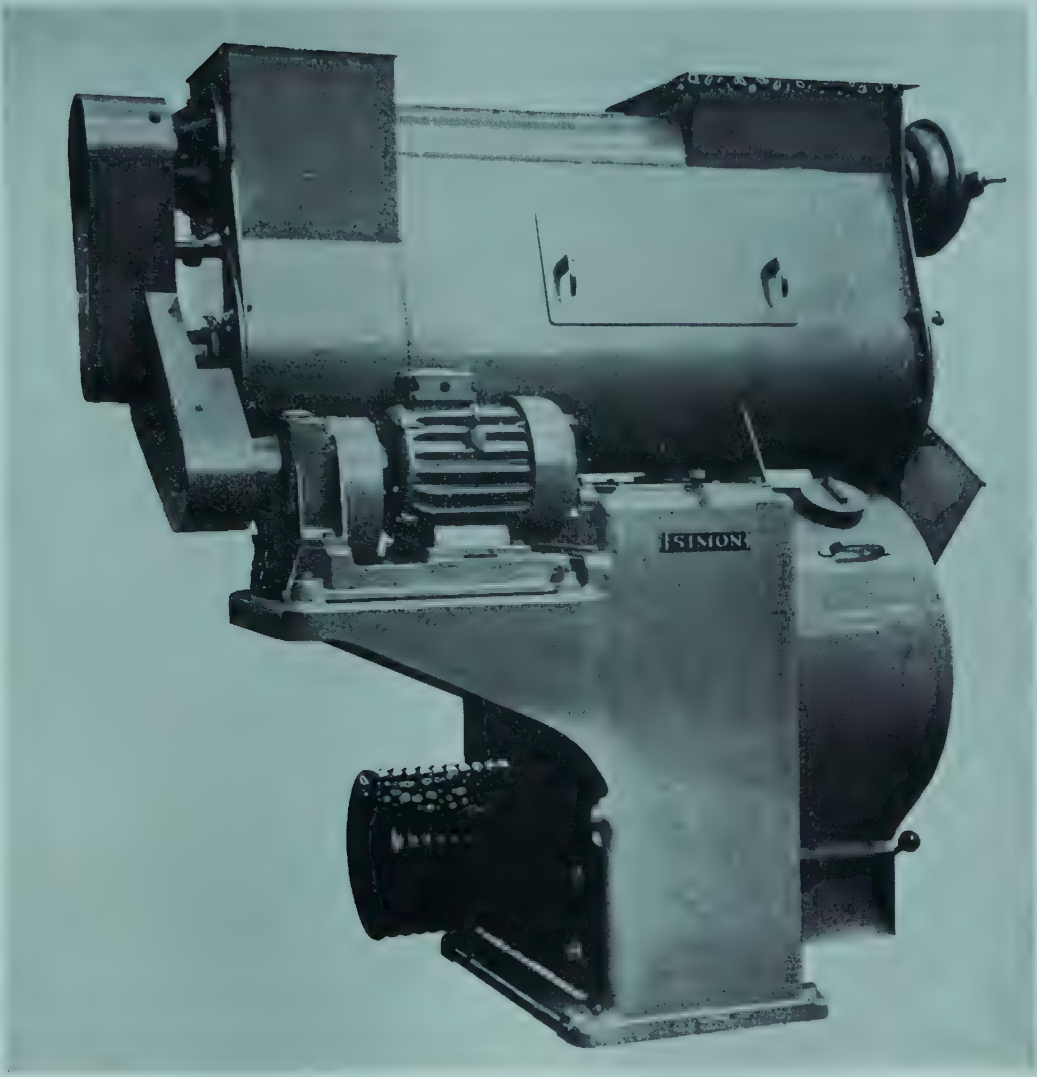


FIG. 144B.—Simon Century model Californian press.

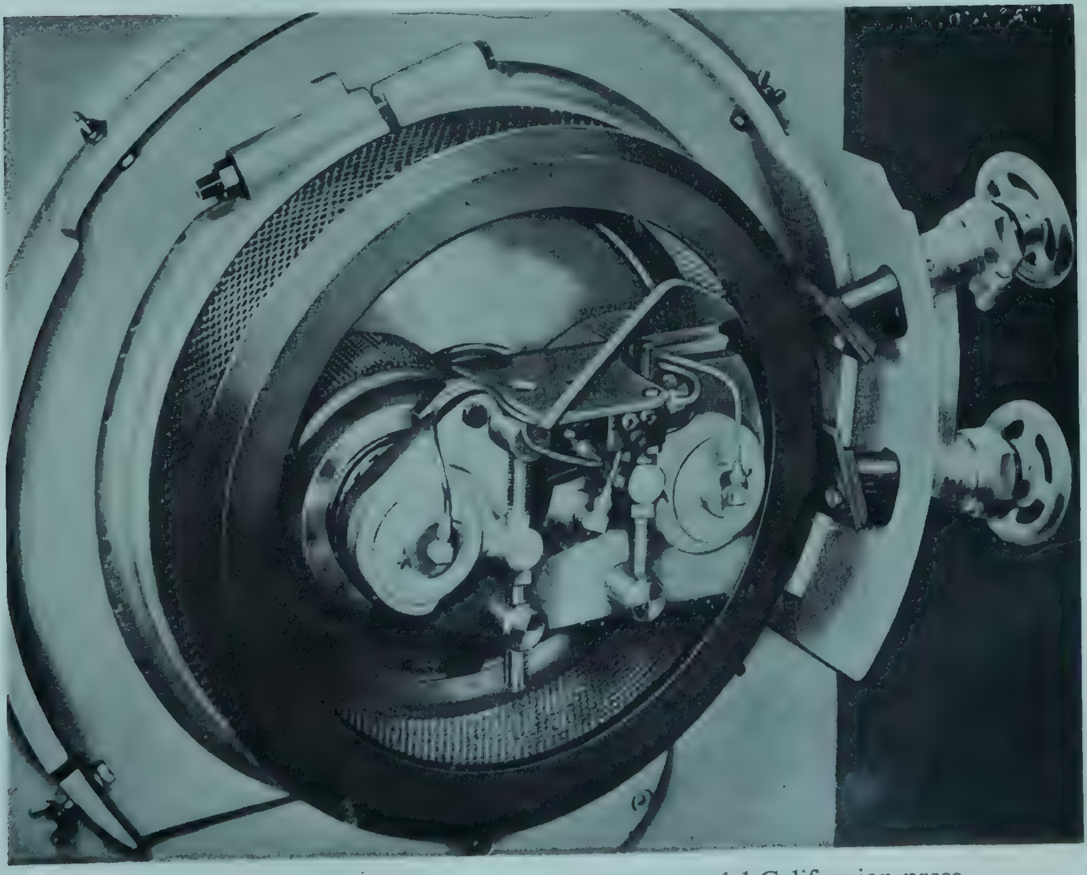


FIG. 144C.—Roller assembly, Simon Century model Californian press.

Chapter XIV

PRACTICAL CUBING AND PELLETING

PRACTICAL cubing and pelleting may be discussed under three headings :

(1) The preparation of the compound meal.
(2) The operation of machines.
(3) The maintenance of machines.

(1) THE PREPARATION OF THE COMPOUND MEAL

The blending and mixing of compound meals is described in Chapter XII, but attention should also be given to the following aspects of preparing the compound meal for cubing or pelleting :

(*a*) Composition and oil content.
(*b*) Uniform particle size.
(*c*) Density or volume.
(*d*) Separation of foreign matter.

(*a*) COMPOSITION AND OIL CONTENT

Certain feeding stuffs are more amenable than others to cubing or pelleting. The most suitable are those containing a high percentage of oil, such as the oil cakes, because oil lubricates the meal in its passage through the die, and the most unsuitable are those containing much fibre, as, for example, grass meal. Most of the high protein materials are good for cubing, but the carbohydrate foods in general are usually difficult to handle.

A compound miller must therefore study the choice of his feeding stuffs when making up his compound mixture not only from the point of view of cost, profit and feeding value, but also with an eye to obtaining the best production results from his cubing machine. The composition of the raw material affects the cubing and pelleting operation, not only in regard to the quality of the resultant cubes or pellets, but also in regard to the hourly output, particularly in the case of small pellets, which are more difficult to manufacture than larger cubes. Further, the abrasive properties of certain feeding materials should be considered in relation to the wear of dies and rollers and the maintenance costs of the machine. Present day limitations to the choice of materials make it difficult to satisfy fully all these considerations and, for that reason, proper liaison between the commercial manager, the laboratory and nutritional expert, the practical miller and the engineer is all the more necessary.

(*b*) UNIFORM PARTICLE SIZE

Uniform particle size assists cubing and pelleting performance; the appearance of the cubes and pellets is improved and the output increased, in some cases, up to 10 to 15 per cent. For cubing, a relatively coarse and granular meal is best; when steam is added, a fine, floury meal tends to paste, making extrusion more difficult and, in some machines, causing the rollers to jam or slip. For pelleting, a finer meal than for cubing is necessary. Otherwise pieces of husk or grits will be evident in the pellets, thus spoiling their appearance, splitting them into two or more pieces and causing more dust and chippings.

(*c*) Density of Volume

If the regular hourly production of cubes from various mixtures is to be maintained, the weight per cubic foot of the compound meal requires attention in so far as the nature of the raw materials available allows. A compound, containing much light, fibrous material, and weighing say 25 lb. per cubic ft., produces less weight of cubes per hour, and in about the same proportion, than a compound containing heavier materials and weighing say 30 lb. per cubic ft. Very light fibrous material, such as low quality grass meal, if cubed on its own, produces only $\frac{1}{4}$ to $\frac{1}{3}$ of the weight of cubes produced in one hour by the average compound. (See Grass Cubing, Chapter XVI.) Usually the amount of live steam absorbed by the meal is similarly affected, the heavier material absorbing more steam.

(*d*) Separation of Foreign Matter

An efficient electric magnet should be placed immediately before the cubing machine because many types of machine are particularly liable to damage from tramp iron becoming wedged between the rollers and die. Care should be taken to see that the magnet is set at the correct angle of 50° and that the stream of feed is not above 2 in. thick. Other foreign materials, including non-ferrous metals, are separated in the intake plant as already described, and are not so liable to enter the meal before the cubing machine as, for example, a bolt off the elevator feeding the machine.

(2) THE OPERATION OF CUBING AND PELLETING MACHINES

When starting up a new cubing or pelleting machine of the extrusion type, the procedure is as follows :

(*a*) Checking of Installation

The first consideration is to ensure that adequate arrangements have been made for the regular supply of meal, steam and molasses to the machine. It is important to check these points before starting up, as continuous running and accurate adjustments to the cubing operation depend on an uninterrupted supply from these sources. Machines fitted with ratchet feeder worms must work on a full spout with an overflow spout taking the excess feed back to the mixers or buffer bin. If the worm is not full, the feed cannot be regular.

Machines employing kettles may have a level indicator to inform the operator by an alarm or light when the kettle is full. Alternatively, the level indicator may be set to prevent the kettle overflowing by stopping the motor driving the machine before the kettle.

(*b*) Steam

Irregular steam pressure affects cubing results very considerably and may even cause blockages through variation in the moisture content of the meal.

To ensure that the pressure remains steady and not subject to fluctuations in the boiler pressure, an efficient reducing valve should be fitted before the cubing machine. For an output of 2-5 tons per hour of cubes, the boiler should be capable of a working pressure of 80-100 lb. per square in. which should be reduced to about 30-50 lb. per square in. before reaching the cubing machine, thus ensuring sufficient reserve. Similarly, the temperature of molasses should be kept constant to ensure even flowing and correct measurement, as explained in the chapter on molasses. The quantity of steam required for one cubing machine varies approximately between 200-500 lb. per hour for 2 ton and 5 ton per hour machines. This figure allows for the warming of the molasses.

(*c*) The Running in of New Dies

Before attempting to obtain any production from a new die in an extrusion machine, it is important to polish the interior surface of the holes by hand feeding the die with a specially prepared mixture of oily meal. The high degree of polish necessary for even cubing and pelleting, maximum output and low power consumption is obtained by the passage of meal through the holes and not by drilling, broaching or reamering. Moreover, the interior surfaces of die holes leaving the works tend to vary slightly in finish because they are processed either independently or a few at a time.

Compound meal, if forced through a new die, takes the line of least resistance through the smoothest holes and, in so doing, accentuates further the discrepancy between the smoothest and the roughest holes so that the latter become increasingly difficult to start at all. In this way, the hourly output and total life of the die will be reduced and, if some holes do not extrude meal as easily as others, the resultant cubes and pellets will vary in length, firmness and polish.

It is, therefore, important that all holes receive the same polishing from the start, and owing to the relatively rough nature of the holes, this can only be ensured by the use of oily meal which extrudes easily. Linseed meal is ideal for the purpose but, if not obtainable, weatings or a similar meal mixed with linseed or cod liver oil in the proportion of a gallon of oil to a ½ cwt. of meal, is satisfactory. After it has been ascertained that all holes are working, the running in operation may be speeded up by the admixture of a more abrasive material, such as hard cubes or pellets. Pellet dies require more running in than cube dies and steel dies more than bronze. For steel pellet dies, particularly chick dies, a day's running in is not excessive. Even when the feed is put on the machine, maximum output and minimum power consumption may not be obtained for some days.

(*d*) Starting Up a Cubing Machine

The operation just described is, of course, only necessary with a new die. Normally machines will start without such preparation provided that, when they are stopped for more than a few minutes, oily meal is hand fed into the die until all the holes are full. Ordinary meal, if left in the holes, will become hard and prevent the machine from functioning until the holes are drilled out or boiled out. (See Dies, p. 189.)

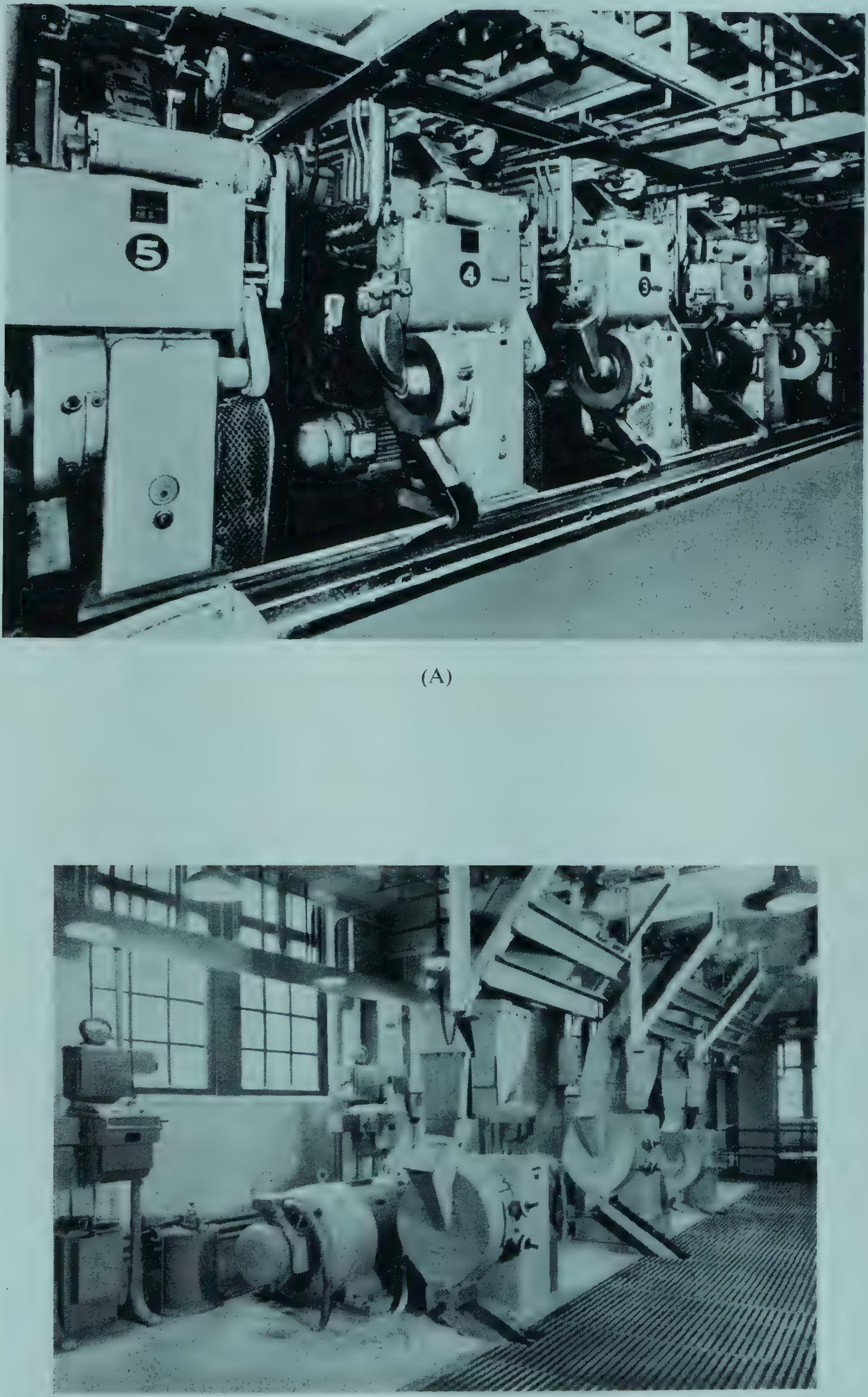
The starting up procedure with most types of machine is as follows:

(1) Check that there is sufficient mixed meal in the buffer bin and that the molasses has been warmed to the correct temperature of 100°-120° F. and is in readiness in the intermediate tank.
(2) Check steam pressure (see p. 185).
(3) Draw off water in steam pipes.
(4) Start cubing machine. It is now assumed that machine has been oiled and greased, checked mechanically, knives set and dies run in.
(5) On some machines it is better to ensure that meal will not immediately enter cubing section of machine until properly steamed.
(6) Start electric magnet before cubing machine.
(7) Start feed from buffer bin.
(8) Set low feed on ratchet feeder. On some machines kettles must be filled first.
(9) Turn on steam and adjust quantity to the requirements of the meal.
(10) Test condition of steamed meal by hand. Temperature of meal should be in region of 120° F. according to conditions and nature of material.
(11) Turn on molasses or cod liver oil and adjust quantity required. *Note:* In batch plants, cod liver oil is added in batch mixers.
(12) When satisfied with condition of meal, put molassed steamed meal or oiled steamed meal into cubing or pelleting section of machine.
(13) Watch ammeter of cubing section motor and gradually increase feed as power consumption permits, and as die wears in.
(14) Adjust quantity of steam and feed in relation to power, quality and output.

(*e*) The Function of Steam and Water

Steam helps the cubing or pelleting operation and assists the flow of molasses. For manufacturing purposes, it is only necessary to heat or steam the meal to that temperature which gives the best cubing and pelleting results as regards appearance, rate of output, power consumption and moisture content of the compound under treatment. The effect of steaming on the nutritional qualities of the meal depends upon the nature of the ingredients and the degree of cooking to which they are subjected, but generally the effect is small. There is little cooking effect since boiling point is only attained by the meal for the short time which it takes to pass through the machine. The time factor varies with different types of machine, but in all cases is only a matter of a few minutes. Machines employing kettles take the longest time and, therefore, give more cooking or steaming than those employing mixing worms.

If cold meal is cubed, machines suffer excessive friction between die and rollers, thereby increasing wear, replacement costs, the power factor and the tendency for the cubes or pellets to crumble. Steam assists the cubing operation by acting as a lubricant to the meal in its passage through the die and by reducing the power consumption in the same way as meal containing a high percentage of oil. Also, the increased temperature caused by steam has the effect of disrupting the oil cells, thus fully releasing any oil left in the cake meals from the oil extraction process.



(A)

(B)

FIG. 145.—Lines of Californian presses.

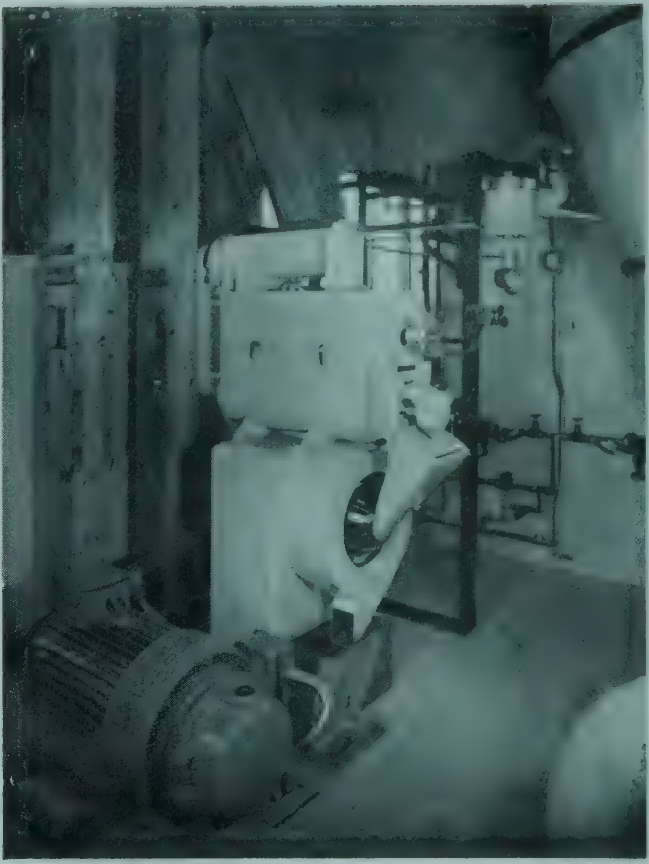


FIG. 146A.—A typical master model cubing installation.

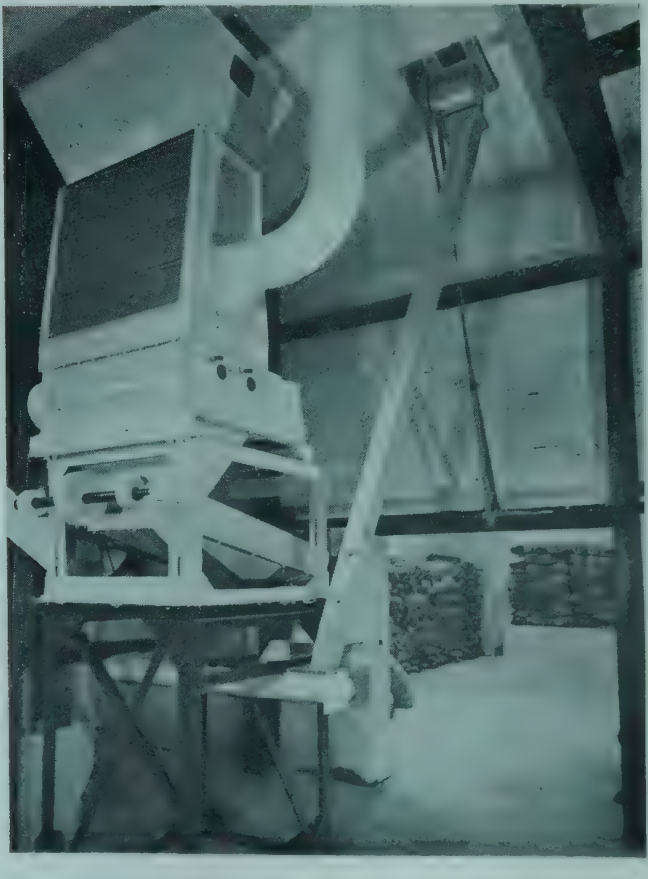


FIG. 146B.—A typical master model cooling installation.

Steam is almost always added in the cubing and pelleting processes in live form instead of through steam jackets, because the former method imparts moisture to the meal thus correcting the moisture content. Also live steam helps to bind the cube and at the same time has the advantage of being able to warm and inject molasses. Steam jackets, which have a drying effect, are not so often used because there is not generally such a need to extract moisture from compounds in the cubing process.

On the other hand, excessive moisture is not suitable for cubing; it causes blockages, particularly when starting up, and when live steam is used, water strainers should be fitted as near as possible before the point of injection and pipes should be properly lagged. Excessive steam or moisture accentuates the natural tendency of cubes and pellets to swell as they emerge from the die plate, and it causes cracks in their surfaces thus spoiling their appearance and making them more liable to break up in the cooler or sack; also it gives the cubes and pellets a rough, dull surface instead of the brightly polished, attractive coat that results from correct treatment.

However, cold water jets are sometimes fitted to cubing and pelleting machines as well as live steam jets to give more flexibility. In certain conditions it may be necessary to increase the moisture content of the meal through the partial use of water to prevent overheating with excess steam. For example, when pelleting $\frac{3}{32}$ in. chick pellets, extra frictional heat is set up (see Dies, p. 189) and, if the temperature is further increased by steam, it may be too high for good pelleting; cold water offsets this heat to some extent and adjusts the moisture content for best pelleting results in conjunction with a little steam. Similarly, water may be used with dry, fibrous materials such as grass meal. (See Grass Cubing, Chapter XVI.)

When the ideal adjustment of either steam or water is arrived at, it is most important to keep the temperature and moisture content constant. The rate of passage of meal through a die is determined by the frictional resistance between the meal and the inside surface of the holes. This is partly affected by the surface polish of the holes (see p. 185), by the size of hole, taper, thickness and countersink (see p. 190), and also by the temperature and moisture content because they all contribute to the resistance to the passage of the meal. Meal becoming suddenly softer through excess moisture will not push the harder meal in front of it through the die holes and, if blocking occurs in this way, the only method of restarting the holes, apart from taking the die out and drilling or boiling them out (see p. 189), is to feed something harder into them, such as hard cubes or pellets.

(*f*) BINDING AGENTS

Molasses

As a binding agent, molasses is not essential for the manufacture of cubes or pellets. Live steam is sufficient to make a good quality and economical product. In fact, in some conditions, water only makes a satisfactory cube in appearance as, for example, in grass cubing, although for general purposes it is not to be compared with steam for the reasons explained above. Molasses is used in compounds mainly because of its appetising flavour, palatability and relative cheapness. There is no doubt, however, that molasses improves the binding properties, the surface polish and the appearance of the cubes or pellets.

The percentage of molasses used in compounds has varied in recent years because of irregular supplies but, for best manufacturing results on extrusion machines, it should be in the region of 10 per cent for cubes and 2½ per cent for pellets. More may be used with moulding machines (see p. 170). Cod liver oil is used in pellets more often than molasses; the former is used for its vitamin content, and its binding qualities, although beneficial, are largely incidental.

(*g*) Factors affecting Output and Power Consumption

The output of a machine, apart from the nature of material, is governed by the amount of power available in relation to the quantity of feed, the construction of the dies and the degree of steaming to which the meal is subjected. As already referred to, maximum output is obtained by using as much steam in the meal as the maintenance of good quality will allow. Steam reduces power and, other factors being equal, reduced power means that the machine will take more feed.

A die with large holes offers less resistance to the passage of the meal than a die containing a much greater number of small holes because the area of metal or ‘ land ’ in the former is less. Consequently a ¾ in. diameter hole die has a much greater output and takes less power than a $\frac{3}{32}$ in. diameter hole die.

Output and power consumption are also affected by the even running in of dies as already described, and by the wear of dies and rollers when the machine is in operation. A thinner die or one with holes tapered steeply has a greater output and uses less power than a die having the reverse construction, but on the other hand the former does not compress the cubes or meals so firmly. Insufficient compression or binding will cause loss of output through breakage of the cubes or pellets and the manufacture of excessive dust and chippings.

More dust occurs with pellets than cubes, but in either case the quantity separated by the cooler sieve should not exceed 3 per cent of the total production. Elevation or excessive handling of cubes or pellets before cooling also causes too much breakage and loss of output besides spoiling their appearance.

(*h*) Quality and Size of Cubes and Pellets

It has been mentioned that too much steam or molasses gives soft cubes of dull appearance. On the other hand, excessive hardness in cubes is not desirable because the animal has to chew them; the ideal is an evenly shaped product, hard enough to prevent breakage and having a brightly polished surface. The requirements of pellets are similar except that, as poultry swallow them whole, farmers usually prefer them as hard as possible.

The length of cubes and pellets is controlled by the rate of passage of the meal through the die and the period of time which elapses between each cube or pellet being cut off. The time is controlled by the number of knives used, the number varying in different types of machine according to the speed of the die or the knife shaft. The most convenient length of cubes and pellets for livestock to eat is usually slightly in excess of the width. For example, a $\frac{1}{2}$ in. diameter cube should be about $\frac{5}{8}$ in. long, and a $\frac{3}{16}$ in. diameter pellet should be about $\frac{1}{4}$ in. long. Cubes may be longer according to requirements, but pellets should be more exact, particularly chick pellets, because undue length is dangerous and is liable to choke the birds. Similarly, individual pellets should not vary in length but slight variation in a cube, although undesirable, on account of appearance, is not so serious. Although usually referred to as cubes, nuts is a more accurate term because they may be round, square or oval in diameter. Pellets are always round. The round shape is becoming more popular because the dies are easier to manufacture and no broaching of the holes is necessary. Also the cubes have a more polished surface without the same liability as the square product to crack at the corners which may result in breakage. On the other hand, square cubes have their corners slightly rounded in the broaching process which improves their polished surface and offsets, to some extent, their tendency to crack.

(3) MAINTENANCE OF CUBING AND PELLETING MACHINES

Assuming that proper attention is given to oiling and greasing, the main wearing parts of extrusion machines are the dies, rollers and knives, or, in some machines, compression worms and slippers. Manufacturing costs are saved by care of these parts.

(*a*) DIES

Dies are initially expensive replacements and careful treatment results in a saving of the cost per ton of cubes or pellets produced. If the die holes become blocked while in use, and the hand feeding of hard cubes or pellets fails to restart them, it is more economical to remove the die and fit another. This prevents friction and wear in trying to force the packed meal through the holes and avoids uneven cubing or pelleting as described on page 185. A satisfactory method of clearing the holes is to place the die in a pan of oil over a small heater and boil it for about 6 hours or until the compressed meal is easily pushed out. An outhouse should be kept specifically for this purpose and a spare die of each size should always be on hand.

The useful life of the die ends when it is so reduced in thickness that the cubes or pellets are insufficiently compressed, and also when the walls of the holes begin to collapse, thereby forming twin pellets. Pellet dies are much thinner than cube dies owing to the smaller area of material to be compressed and the greater frictional resistance of the material passing through. Therefore, they never last as long as cube dies and, owing to the greater frictional resistance, pelleting is always harder than cubing.

Pellet dies are made of special steel or bronze and cube dies of steel. To prevent wear, steel dies may be subjected to a hardening process or they may be sprayed with ‘ fescol ’, known as fescolising. Therefore, they last longer and give a greater total tonnage than bronze dies and for this reason are generally more popular. On the other hand bronze, being softer, extrudes more easily and does not require so much running in as hardened steel, which explains why bronze is used in some machines on the harder pelleting operation.

All pellet holes of $\frac{3}{16}$ in. diameter down to those of $\frac{3}{32}$ in. diameter are drilled parallel throughout with small countersinks on their inlet side. Cube holes of $\frac{3}{8}$ in. diameter upwards, besides being countersunk, are usually tapered for about half and, in some machines, more than half their depth, the shorter and outlet portion being parallel. As the die wears, the top surface becomes uneven and the countersinks burr over. Dies may then be skimmed and the countersinks redrilled. To prevent excessive wear of the softer metal underneath, fescolised dies should be refescolised immediately the fescol plate has worn off. Hardened steel dies are, of course, harder to skim than bronze dies but usually some extra life can be obtained by reconditioning. Skimming and countersinking at frequent intervals will increase hourly output and total life, particularly with pellet dies.

The performance of a cubing or pelleting machine depends to a large extent on the construction of the die. A great deal of skill and study is required in the choice of materials, thickness of die, taper of the holes and the size of countersink. These factors vary according to the size of the cube or pellet to be made and affect the capacity of the machine, the quality of the product and the manufacturing costs.

(*b*) Rollers

Rollers are made of special hardened steel and have flutes ground on their surface to reduce skidding or slipping and to grip the meal. After a time these surfaces become worn through friction with the meal and die, and, in some machines, they may be levelled off and refluted; in others, such as the Master Model and Century, new sleeves may be shrunk on the existing roller framework in place of the worn sleeves. Spare rollers or spare sleeves should always be carried in stock. Single rollers should never be changed without changing the complete set and, wherever possible, as in the Master Model and Century machines, one set of rollers should work in conjunction with each die. Worn rollers should not be fitted with a new die or vice versa because the worn surface will spoil the new, and the output of the machine will be reduced through the surfaces not coinciding. With machines in which the rollers are adjustable, care should be taken to see that the rollers are not set too closely to the die or the die holes may be burred over; they should just revolve without meal in the machine.

(*c*) Knives

Most types of knives may be resharpened on an ordinary oil stone. Stationary straight edge knives tend to wear more quickly than circular revolving knives because, in the former case, the wear comes in one place and coincides with each row of holes, whereas with circular knives the wear is spread round the circumference. Knives should be set about $\frac{1}{16}$ in. away from the die to allow for the ' play ' of the revolving die or knife bracket; in some machines, they may have to be set further away to obtain the desired length of cube or pellet.

Chapter XV

CUBE AND PELLET COOLING

THEORETICALLY, the problem of treating hot, moist cubes as they leave the cubing machine is similar to that of grain drying. As in grain drying, cooling would be a much simpler matter if the excess moisture was first dried out by hot air. From the practical point of view, however, the expense of using hot air for cubes is not justified, particularly as machines using cold air only give satisfactory results.

To ensure satisfactory storage, cube cooling is not simply a matter of cooling the surface but a question of controlling the temperature and humidity right through the cube. Precise figures for temperature and moisture content that will give the best storage life for cubes or pellets have not been determined owing to a large number of varying factors, such as climatic conditions, season, nature of raw materials, and the size and shape of the cube. As a guide, however, cubes or pellets, when stored in bags, should not normally exceed a temperature of 75° F. or a moisture content of 12½ per cent.

FACTORS AFFECTING EFFICIENCY OF COOLING

These may be summarised as follows:

(*a*) Gentle handling of cubes between cubing machine and cooler to minimise dust and chippings.
(*b*) Even distribution of the mass or layer of cubes to assist air circulation.
(*c*) The shape and size of cubes in relation to air circulation and packing of the mass.
(*d*) The advantages of suction, whereby dust laden air is drawn through the cubes into a cyclone, thus avoiding any tendency of leakage into the mill atmosphere as occurs with any method of blowing.
(*e*) The temperature of the air in relation to the cube.
(*f*) Automatic control of the cooling time, i.e. the rate of flow through the machine.
(*g*) The quantity of air in relation to the rate of cube flow.
(*h*) The rate of diffusion of heat and moisture from the centre of the cube to the surface.

(*a*) HANDLING

Severe handling of hot cubes and pellets leaving the cubing machine due to elevating them, or giving them too long a fall into the cooler, causes excessive dust and chippings and should be avoided because it spoils their appearance and reduces production capacity. Also, excessive dust affects the cooling efficiency by obstructing the passage of air between the cubes or pellets and, in some machines, by blocking up the air apertures.

(*b*) DISTRIBUTION

As the cubes enter the cooler, the flow must be properly distributed and spread into even layers in the various ways described with different types of machine.

(*c*) SHAPE AND SIZE OF CUBE

Shape and size affect the packing of the cubes in the cooler and consequently the circulation of air through the mass. The effect is, however, relatively slight. Square cubes pack more tightly than round cubes because the area of surface contact of the former is greater and, therefore, the air does not penetrate the mass of cubes quite so easily. Pellets, being smaller, pack more tightly than cubes and contain more dust, which further retards air circulation.

(*d*) SUCTION

Air should always be drawn through coolers by suction in preference to blowing, because cold air that has passed through cubes is warm, moist and laden with dust. If the air is drawn through the cubes by a suction fan and collected by a cyclone, the dust is separated before the clean air escapes to the outside atmosphere. But, in any method of blowing air through the cooler, a certain amount of the warm, moist, dust laden air tends to be forced out of the machine directly into the area surrounding it, resulting in waste and unpleasant working conditions. Also, the evaporated moisture condenses on inside surfaces in the mill, causing corrosion and unpleasant dripping of water.

(*e*) AIR TEMPERATURE

A cooler under suction, as distinct from any blowing method, draws fresh, cold air from the atmosphere through the cubes and, provided it is situated in a relatively cool place, has the maximum cooling efficiency in relation to the warm cubes.

(*f*) AUTOMATIC CONTROL OF COOLING TIME

To ensure even cooling in gravity coolers, the time that the cubes take to pass through the machine must be constant assuming, of course, that there is a relatively small variation in the feed to the machine. This is achieved by electrical stop and start devices, a mercury switch and a bin level indicator, as detailed on pages 196 and 199. In this way, the cubes are always kept at the same level and pass through at the same rate. If the level in the bin drops because of cubing irregularities, the discharge gate on the cooler is automatically stopped by the release of the bin level indicator and is restarted when the cubes again rise to the required level and depress the indicator. In the Sizer ‘ Flare ’ cooler, a different principle is used in which the air is controlled by a slide which adjusts the air flow according to the height of the cubes in the cooler. In conveyor coolers, the cooling time cannot vary so long as the speed of the band or chain is constant.

(g) QUANTITY OF AIR AND RATE OF CUBE FLOW

The quantity of air in relation to the speed or rate of flow of the cubes through the cooler will obviously affect the efficiency of cooling and drying.

As explained on page 201, a gravity cooler uses only about half as much air as a conveyor cooler of the same capacity and the cubes remain in the gravity machine twice as long. This is one of the main reasons why gravity machines are more efficient than those of the conveyor type.

(*h*) RATE OF DIFFUSION FROM CENTRE OF CUBE TO SURFACE

The slower action of the gravity method results in better cooling because too rapid evaporation causes a hard surface layer which retards the rate of diffusion from the centre to the surface. The heat and moisture retained in the centre of the cube after it is bagged and stored eventually rises to the surface, resulting in sweating and mouldy cubes.

Comparisons between Cube and Pellet Cooling

Because of their comparatively small size, pellets have a much larger surface area than cubes in relation to the weight of material. A bigger proportion of the material, therefore, comes into contact with the air current and the depth from the centre of the pellet to the surface, through which moisture must pass by diffusion, is much less. Therefore, pellet cooling is easier and a simpler type of cooler may sometimes be used for cooling pellets only, provided that the pellets are not allowed to pack in a tight mass.

In practice, however, there are other factors which, to some extent, offset the above and a simple pellet cooler, as described on page 195, must be designed to avoid these conditions as much as possible. These are:

(1) Pellets pack more tightly in bin type gravity coolers than cubes, thus reducing the air passages between them.

(2) The pelleting operation makes more dust which retards air circulation.

(3) In most conditions the greater pressure exerted in forcing the meal through the small holes of the pellet die plate causes more friction and heat. Pellets, therefore, sometimes have to be cooled down from higher temperatures than cubes.

CUBE AND PELLET COOLERS

There are two types of machine:

(1) Those in which the movement of the material through the machine is effected by a conveyor.

(2) Those in which the movement is by gravity.

(1) THE CONVEYOR TYPE

Conveyor machines have been developed by large compound millers and a few are still in regular use. They have, however, been largely superseded by the more modern gravity coolers, which are chiefly products of the milling engineers.

There are two kinds of conveyor coolers:

(*a*) Those employing wire mesh conveyor bands in which the air is drawn through the underside of the band and the cubes.

(*b*) Those employing canvas bands superimposed in tiers so that the cubes are turned over on the band from tier to tier while air is drawn across them.

In the first type (Fig. 147) the space between the two strands of the conveyor band is divided into compartments, each compartment having its own inlet. The space between the top casing of the conveyor and the top strand is also divided into compartments by hinged partition flaps and, when the conveyor is in operation, the flaps rest on the cubes on the band. The air inlets are connected to a common trunk and fan, but each inlet may be independently controlled by a slide. The direction of the air, as it passes through the machine and out at the feed end, is shown by the arrows in Fig. 147.

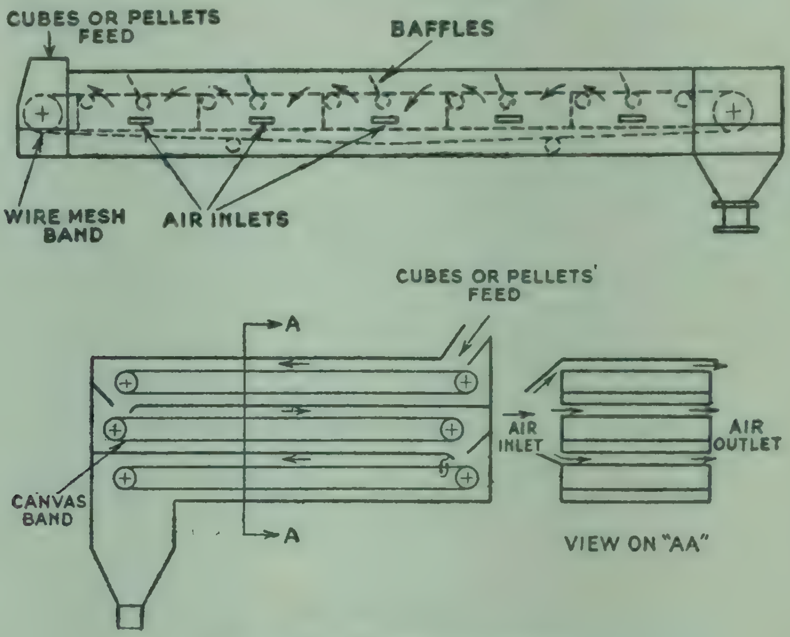


FIG. 147.—Conveyor coolers.

The disadvantages of this type of wire mesh conveyor cooler are :

(1) Lack of control over the amount of dust contained in the air leaving the feed end of the machine which means that a considerable quantity is lost to atmosphere.
(2) If there are any gaps in the flow or unevenness in the layer of cubes on the band, the air takes the line of least resistance and passes straight out of the machine without effectively cooling the cubes.
(3) Wire mesh bands are not very durable and they tend to cause attrition or breakage of the cubes.
(4) Power is required to convey the cubes.
(5) The cooling time is short compared with gravity coolers, but the time varies according to the speed of the band.

In the second type of conveyor cooler (Fig. 147) two, three or sometimes more tiers of cotton canvas bands or similar material may be used. In this machine, the air does not pass through the layer, which must, therefore, be turned over to bring the under surface into contact with the air. The air flow passing sideways through the conveyor may be partially controlled by doors as it leaves the machine. This method is generally more efficient than the foregoing.

(2) THE GRAVITY TYPE

(1) *Simple Gravity Cooler*

One of the simplest forms of gravity machine (Fig. 148) which is normally suitable for pellets only, comprises a series of straight or curved plates which retard the flow of pellets as they pass down a metal leg through which cold air is drawn by a fan into a cyclone. The pellets are turned over as they pass through the air flow from one plate to the other thus exposing as much of their surface as possible to the air. This design prevents the pellets from packing in a mass and promotes air circulation. Two double outlet slides or adjustable flaps control the rate of flow of material through the cooler. Assuming the feed is relatively constant, the cooling time may be controlled automatically by a bin level indicator, mercury switch and electrical stop and start device as explained later.

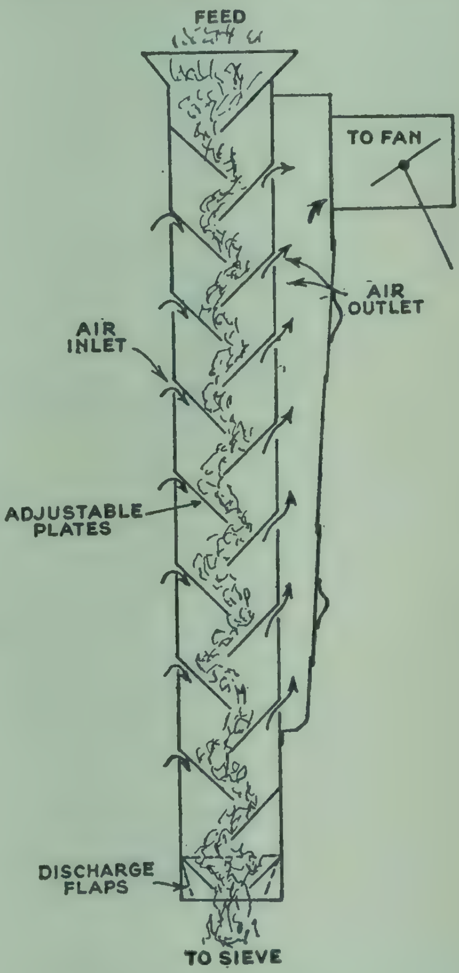


FIG. 148.—Simple gravity cooler.

(2) *The Simon Automatic Cube and Pellet Cooler*

This cooler (Fig. 149) is still widely used but it has now been superseded by the Simon double column machine. The component parts are a circular bin (1) of galvanised sheet iron, made in four sections with air gaps between them, a coned cylinder (2) and an inner coned structure (3); the bin is encircled by an air duct (4) to which the coned cylinder is connected by a duct (5) and the inner coned structure by another duct (6), the circumferential ducts being connected to the suction side of a fan. The bin outlet is fitted with a mechanically driven discharger at (7) which is connected to a stop and start unit (8) controlled by a bin level indicator.

The cubes or pellets enter the bin at the top and are evenly distributed by the coned cylinder. The fan draws cold air through them at a number of different levels, the paths taken by the air being indicated by arrows. The large number of air inlets and the relatively short distance travelled by each air current ensure rapid and uniform cooling by preventing the air from becoming overheated at any one point.

The cooling time is kept constant because the cube level is automatically adjusted. If, for example, there is a sudden falling off in the rate of flow, through a choke in the cubing machine, the cubes in the bin drop below the level of the flap valve or bin level indicator (9). The flap is then released and the electrical stop and start unit, to which it is attached by means of a mercury switch, stops the mechanical discharger on the cooler bin outlet. This prevents the cooling period for the cubes already in the cooler from being shortened, because the cubes are retained in the machine until the flow again reaches the height of the flap valve thereby depressing it and re-engaging the mechanical discharger on the outlet. For the most efficient cooling, the cooler must be kept constantly full. The rate of flow through the machine may be adjusted within close limits for normal running purposes by the outlet flap doors. The automatic control devices are mainly intended as a safeguard in the case of chokes or sudden unexpected variations in the rate of flow from the cubing machine.

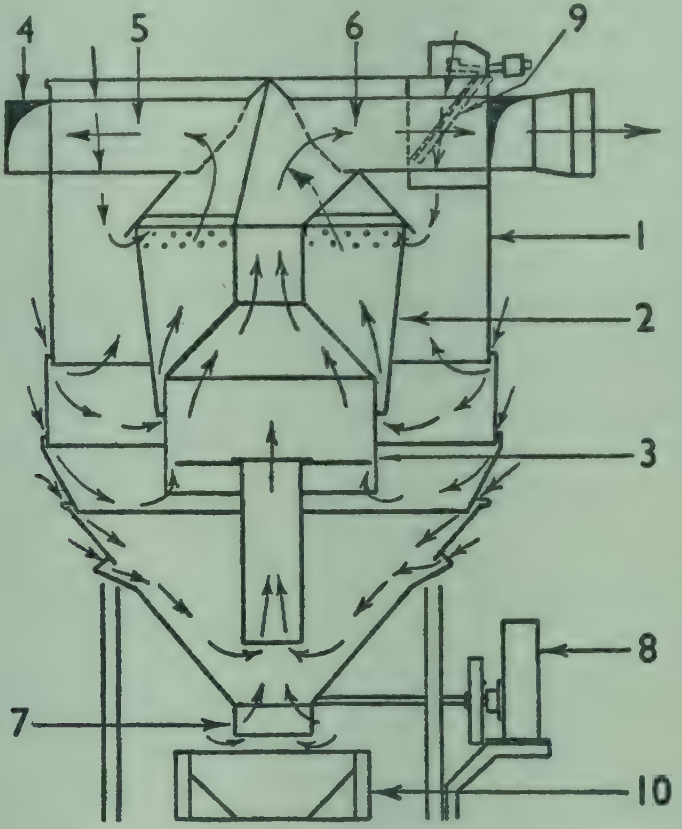


FIG. 149.—Simon heavy duty cooler.

1. Circular bin. 2. Coned cylinder. 3. Inner coned structure. 4. Air duct. 5. Duct. 6. Duct. 7. Mechanically driven discharger. 8. Stop and start unit. 9. Bin level indicator. 10. Oscillating sieve.

The cooled cubes or pellets are discharged on to an oscillating sieve (10) which removes any dust or broken particles. Separate screens of $\frac{1}{4}$ in. open lock mesh for cubes and $20 \times 2\frac{1}{2}$ mm. slots for pellets are fitted into the same sieve frame in such a way that it is unnecessary to change screens when changing from cubes to pellets or vice versa. For chick pellets a screen with 0·069 in. round hole perforated slots is more suitable.

(3) *The Double Cone Cooler*

Another type of gravity cooler (Fig. 150) developed by compound millers, employs an internal coned structure. This machine embodies one cone superimposed over another inverted cone, both of which are perforated and enclosed in a frame. Below the inverted cone, and shut off from the rest of the machine, is an air chamber connected by ducts to a fan. The cold air, which in this machine may be blown or sucked, passes through the perforations and the cubes as they slide down the outside of the top cone and the inside of the inverted cone. The rate of flow of the cubes is controlled by a bin level indicator and the cubes are sieved before bagging in the same way as previously described.

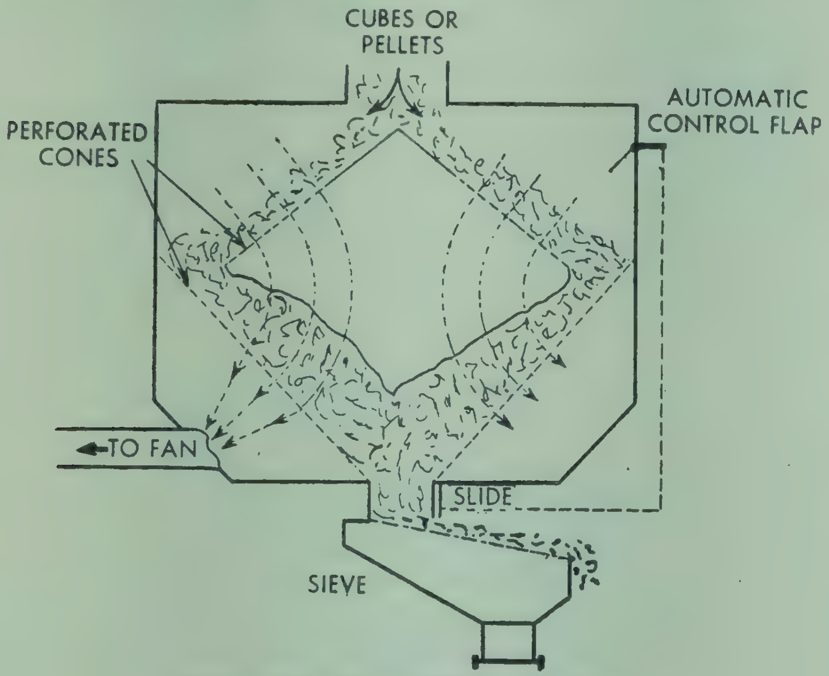


FIG. 150.—The double cone cooler.

(4) *The Flare Cooler*

The Flare Cooler, made by Richard Sizer Ltd., is another type of gravity flow machine. The structure shown in Figs. 151A and B is perforated and louvered on its air inlet and outlet sides, the air being drawn through the cubes as they slowly gravitate down the bin. A plate is fitted between the cooling bin and the bin hopper on which the cubes or pellets accumulate until the machine is full. The plate is then withdrawn by means of a handwheel working through a rack and pinion.

A special feature of this machine is the control of air flow by a slide damper which shuts off one or more of a number of air exit ducts delivering to a common trunk and fan. This adjusts the air flow according to the height of the cubes in the cooler and, unlike most of the other gravity flow machines, results in the cooling being just as efficient if the cooler is full or only half full, as, for example, when the machine is being filled or emptied or, in the event of any variation of flow from the cubing or pelleting machine. When the cube level begins to drop, a warning light is automatically shown by means of a mercury switch and bin level indicator.

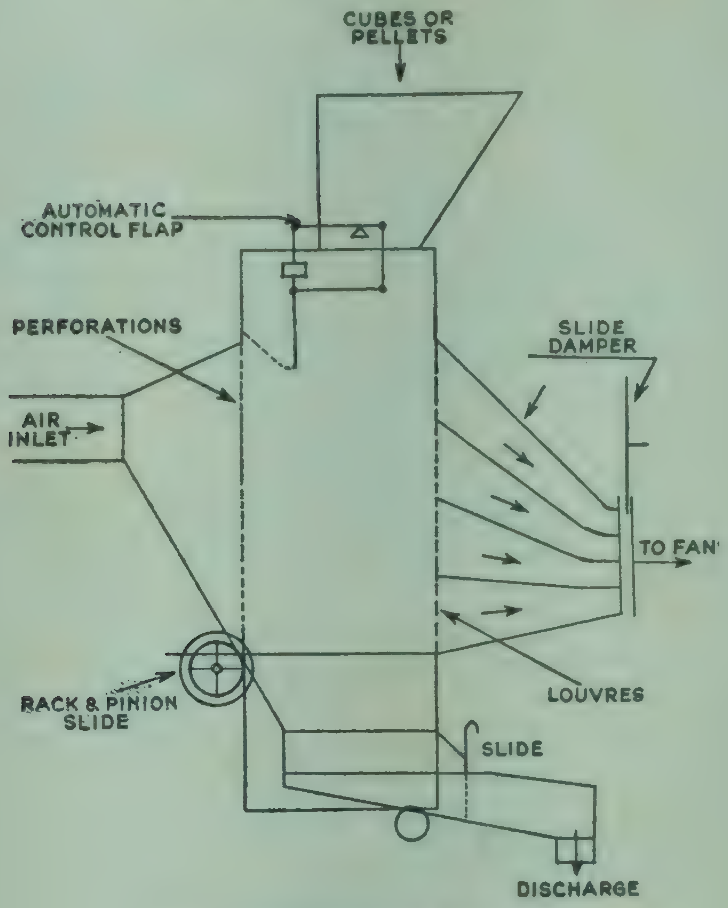


FIG. 151B.—The Sizer flare cooler.

(5) *The Double Column Cooler*

This machine (Figs. 152 A, B and C) is the latest type to be made by Henry Simon Ltd. It may be built in four sizes consisting of standard sections according to the capacity of the cubes or pellets to be cooled. Figs. 152 A and B show a two-section machine, referred to as a $2A^2$ size, the others being 2A (Fig 152 C), $2A^3$ and $2A^4$ respectively. Each section has a capacity of 2 tons per hour of cubes or pellets and is suitable for operating in conjunction with one Master Model Californian press. Two sections are used for a Century Model press.

The cooler consists of a feed hopper, two cooling columns and a revolving paddle discharge gate which is driven by a geared motor. The cubes pass down the cooling columns and cold air is drawn through them by a fan which discharges to a cyclone. The air is drawn from the outside to the inside of each column, of which the outer covers are in the form of perforated sheets and the insides of either louvres or perforated sheets. Underneath the cooling columns, two valves regulate the delivery of cubes through two paddle-bladed dischargers revolving in opposite directions. The discharge mechanism is driven by a ½ h.p. geared motor in the case of the 2A and $2A^2$ machines, and by a ⅝ h.p. motor in the case of the $2A^2$ and $2A^4$ machines.

In order to ensure that the cooling columns are kept full and that the cooling time remains constant, the cooler is electrically controlled on the same lines as described for the other Simon cooler but with slight variations.

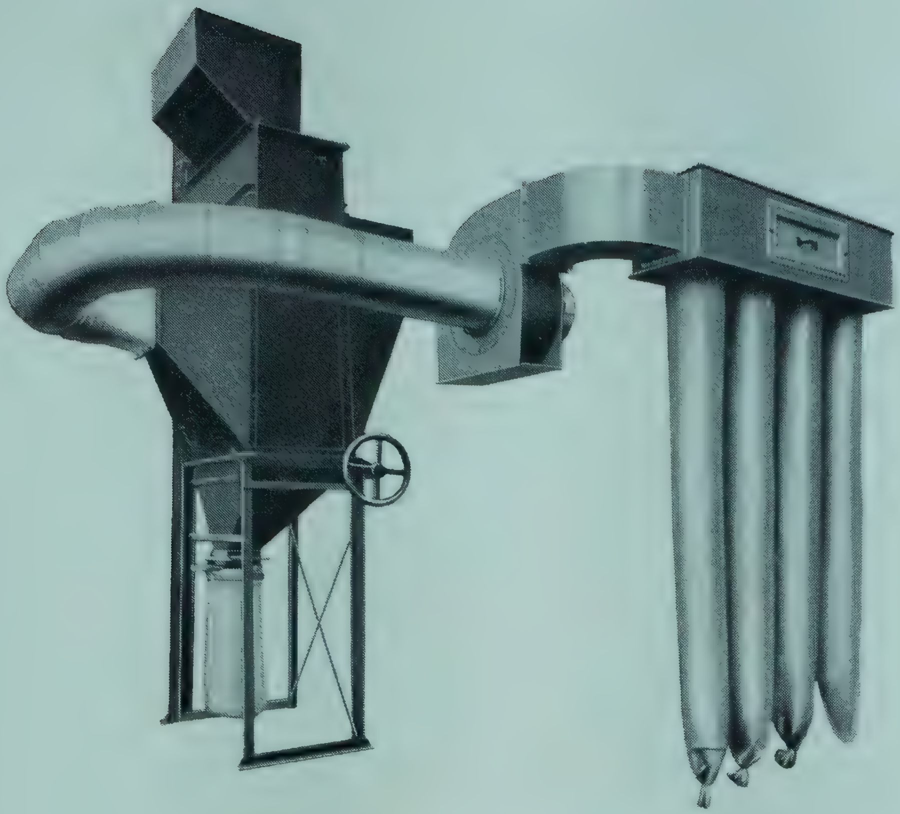


FIG. 151A.—The Sizer flare cooler.

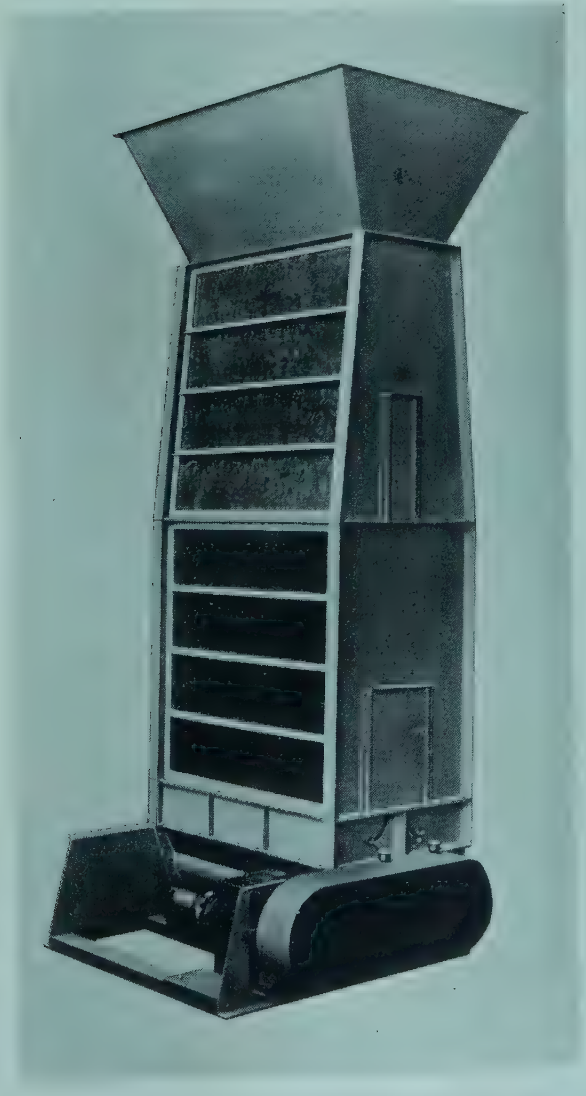


FIG. 152A.—Simon double-column cooler (two-section machine).

A bin level indicator is fitted to the feed hopper and connected to the geared motor so that, if the level of the cubes drops below the indicator flap, the motor driving the discharge mechanism is automatically stopped. Similarly, the discharger automatically re-starts when the cubes reach the level of the indicator flap. It should be noted that a hand control position is provided on the main switch so that the cooler may be emptied when changing from cubes to pellets. An independent oscillating sieve similar to that described on pages 196 and 200 is incorporated after the cooler to extract dust and chippings.

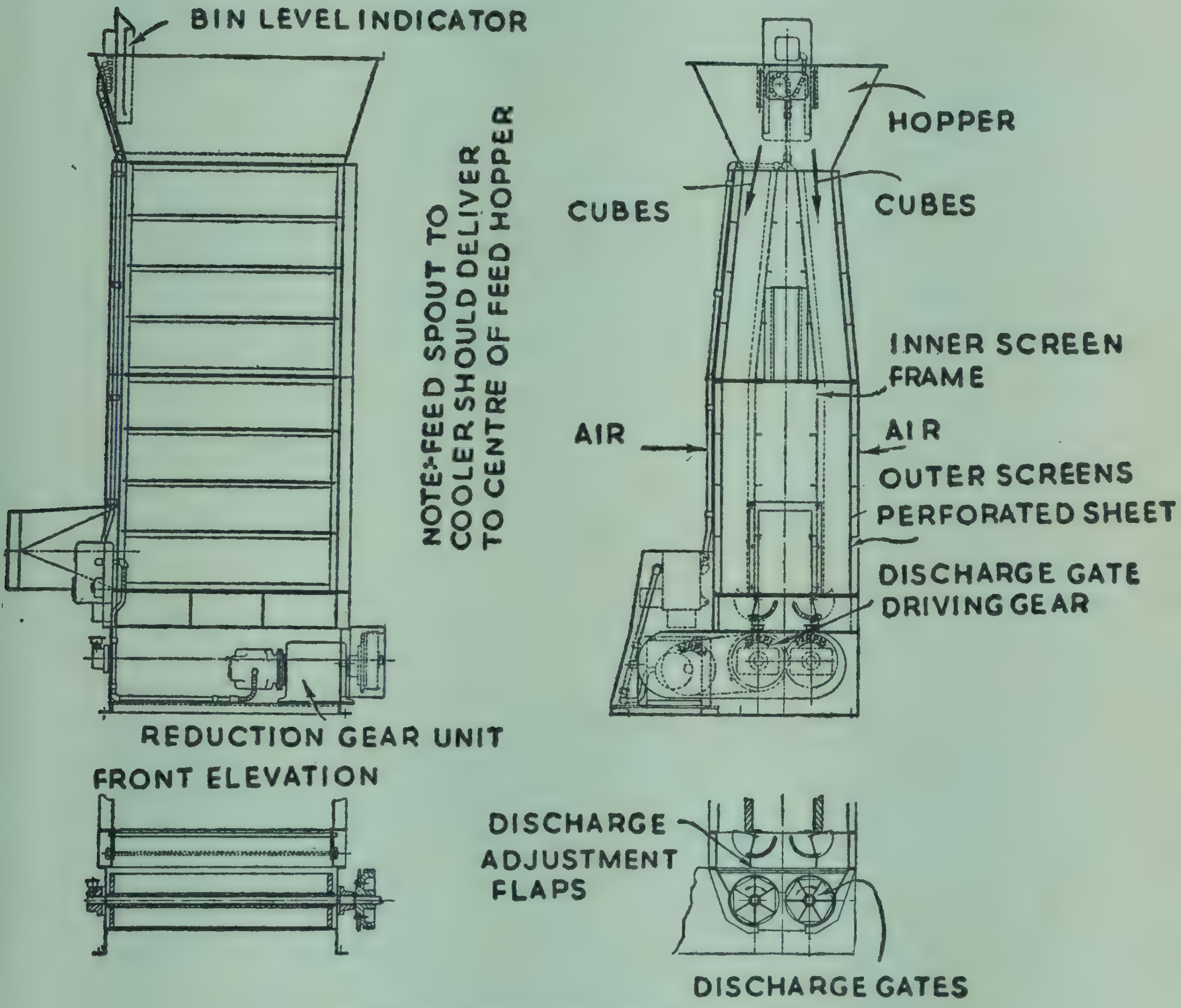

BIN LEVEL INDICATOR
NOTE:-FEED SPOUT TO COOLER SHOULD DELIVER TO CENTRE OF FEED HOPPER
REDUCTION GEAR UNIT
FRONT ELEVATION
HOPPER
CUBES
CUBES
INNER SCREEN FRAME
AIR
AIR
OUTER SCREENS
PERFORATED SHEET
DISCHARGE GATE DRIVING GEAR
DISCHARGE ADJUSTMENT FLAPS
DISCHARGE GATES

FIG. 152B.—The Simon double column cooler.

The Installation of a Gravity Cooler. It is important that a gravity cooler should be installed immediately underneath a cubing machine so that the cubes or pellets deliver into the centre of the cooler. This ensures even distribution of the cubes and consequent even cooling and air circulation at all points. Further, in most gravity machines, a central feed into the cooler is necessary to ensure that the automatic gear controlling the cooling time works consistently. An even stream of feed operates the valve at the top of the cooler and depresses and releases it regularly according to the level of the cubes as explained in the description of the Simon coolers.

Screening before and after Cooling. In this country, there are only a few cases in which screening or sieving is performed both before and after cooling, although it is more common in America. Normally, screening is performed only after cooling, and gives satisfactory results. For the reasons already given, however, the material entering the cooler should be free from dust and chippings and, therefore, pre-sieving improves the efficiency of the cooler in single floor buildings and other cases in which the cubes or pellets have to be elevated and the dust content is likely to be high.

In the Simon cooling plant (Fig. 152 C) a double decker sieve ensures separate runs for cubes and pellets after they are discharged from the cooler. In this way, screen changing is avoided and the cubes and pellets are prevented from mixing together in the event of a small quantity of either hanging up in the cooler when changing over from one to the other. The cubes pass over the top screen into the sack, the small broken pieces and dust passing through the top screen and over the bottom screen back to the buffer bin or cubing machine. Dust passes through the bottom screen and is also returned to the buffer bin or cubing machine. Pellets pass through the top screen and overtail the bottom screen into the sack. When manufacturing cubes, it is necessary to provide a valve to turn the cube chippings back to the cubing machine, and the pellets into the sack when manufacturing pellets, because both overtail the bottom screen. When the cooler is being emptied, provision should also be made for catching off chippings and dust into a bag. This occurs when the cubing machine is stopped for the die to be changed from one size to another. When manufacturing $\frac{3}{32}$ in. diameter chick pellets, better results are often obtained if the dust and chippings are sacked off and not returned because a meal feed of more even texture is achieved. Sizes of screen covers are given on page 196.

Comparisons between Conveyor and Gravity Coolers. Modern gravity coolers are more efficient in their cooling and handling of the cubes or pellets and have a higher capacity than comparable conveyor machines. For the reasons subsequently explained, cubes remain longer in the gravity type, and therefore ensure a more gradual cooling and the consequent diffusion of heat and moisture from the centre of the cube to the surface. Also, the slower, gentler, movement of gravity machines prevents cube breakage and causes less dust and chippings.

Gravity coolers are generally easier to accommodate in the average size mill, although, in large mills with ample floor space, there are exceptions in favour of the conveyor machine. In addition, the design of a gravity cooler allows for the automatic control of the cooling time and the better control of the air flow in relation to the amount of dust carried into the cyclone. Conveyor coolers blow some dust and chippings into the atmosphere, thereby causing waste and unpleasant working conditions.

The capacity and efficiency of conveyor coolers is limited by the speed of the band which controls the time that the cubes are in contact with the cold air. The slowest practicable speed of a band under these conditions is about 5 ft. per minute, so that in the case of a conveyor cooler having a band 30 ft. long, the cubes are only in the machine 6 minutes as compared

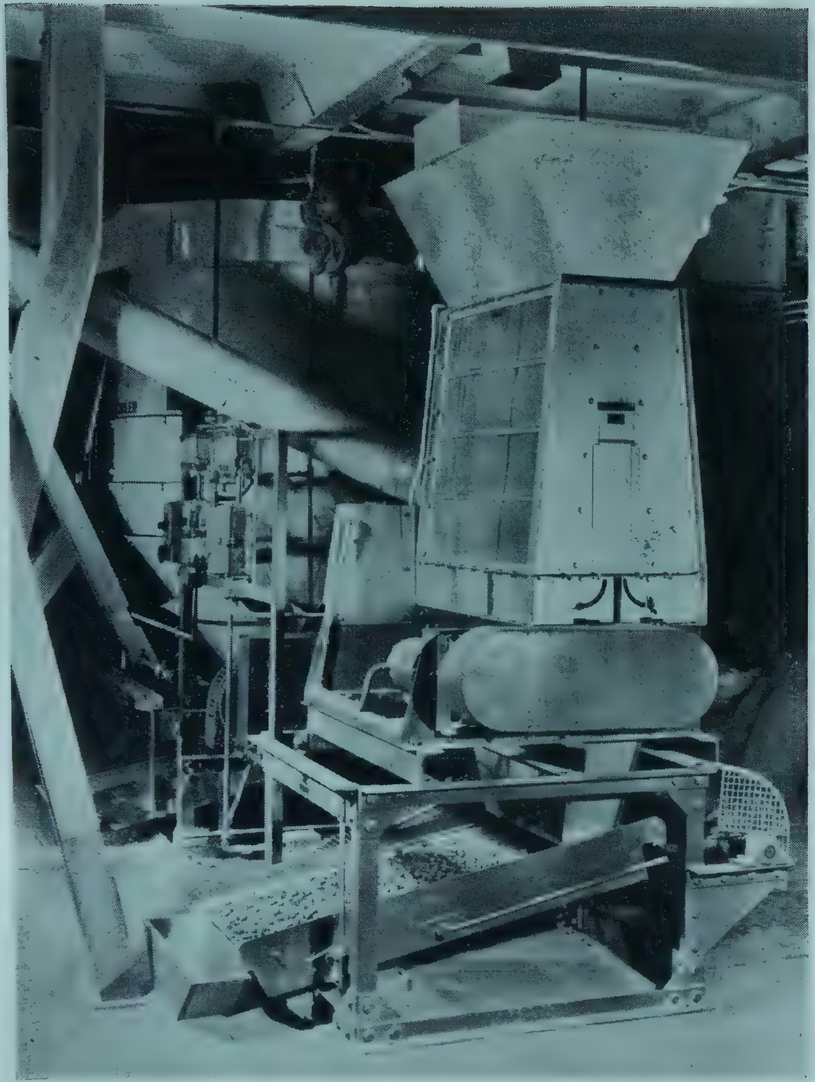


FIG. 152C.—Installation of Simon cooler showing screening arrangements (one-section machine).

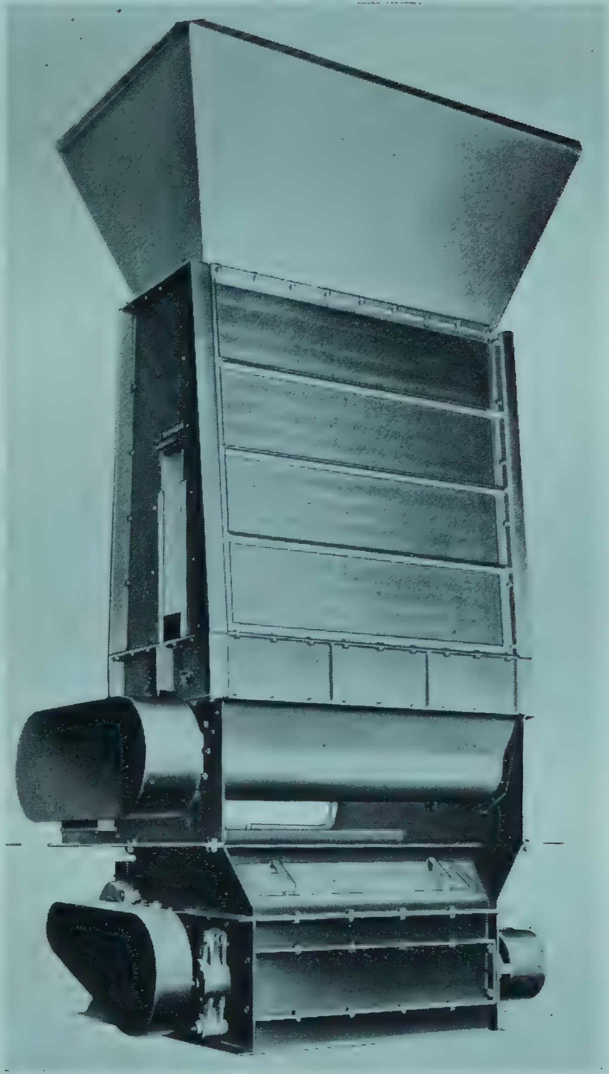


FIG. 153.—The chick crumb roll fitted below Simon cooler (one-section machine).

with 20-30 minutes in most gravity machines. Therefore, in order to obtain more cooling on a conveyor cooler, it is necessary to increase the amount of air, which explains why they use about 6000 cubic ft. of air per minute as compared with about 3000 cubic ft. for a gravity machine of a comparable capacity of 4 tons of cubes per hour. This large volume of air and short cooling time of the conveyor cooler causes excessive surface evaporation from the cube, thereby forming a hard surface layer and retarding the diffusion of the heat and moisture from the centre of the cube.

On the other hand, a point in favour of conveyor coolers is that the shorter time taken for the cubes to pass through the machine means that there is less delay in changing from one size of cube to another. Also, although they occupy more space than gravity machines, they can be slung on hangers immediately underneath floor level, thus leaving the space below free for packing, storage or other use.

THE MANUFACTURE OF CHICK CRUMBS

Chick crumb manufacture has become popular in recent times, partly because many poultry farmers consider that a proportion of 'fines' is desirable for chicks and, partly, because the process itself is more economical than the manufacture of $\frac{3}{32}$ in. diameter chick pellets.

Chick crumbs are made by sizing standard [illegible] diameter pellets on fluted rolls and then grading the throughs into small, even particles similar in size to maize grits.

When manufacturing $\frac{3}{32}$ in. pellets, maintenance costs of most pelleting machines are about four times greater than those of $\frac{3}{16}$ in. pellets; a die having $\frac{3}{32}$ in. diameter holes is usually initially more expensive and the wear is so heavy that its total life in tonnage is about three or sometimes four times less. Rolls and other parts of machines are similarly affected.

Further, when $\frac{3}{32}$ in. pellets are manufactured, labour costs per ton are usually higher because, apart from the increased liability of blockages and other pelleting difficulties on these small sizes, the output from most pelleting machines is only about a third as much as when making the $\frac{3}{16}$ in. size; consequently, in almost every case, the output of $\frac{3}{32}$ in. pellets is below a ton per hour, and is usually only a few cwt., with the result that, unless several machines are employed, there is insufficient work even for one packer or for the mixer men.

When chick crumbs are made, however, maintenance costs are reduced very considerably because rolls require only occasional refluting, and the higher output from the larger pellets reduces labour and overhead charges. Against this, extra power is required to drive the rolls and sieve.

Standard kibbling rolls with differential gearing of 2½ to 1, having five flutes on the top roll and seven on the bottom, may be used for crumb manufacture. A rollermill with two pairs of 40 × 10 in. rolls has an output of approximately 4 tons per hour of crumbs.

Henry Simon Ltd. manufacture a pellet crumbler, consisting of one pair of 6 in. diameter specially fluted rolls, which is designed to fit directly under the 2A range of coolers as shown in Fig. 153. The crumbler, which is only 20 in. in height and driven by a 5 h.p. motor through vee belts, can also be used independently in almost any type of installation. A by-pass is arranged from the cooler so that, if desired, $\frac{3}{16}$ in. pellets and cubes may be sacked off without treatment.

Grading is usually performed by a double decker oscillating sieve, the top screen overtailing large pieces, and the bottom screen overtailing the finished crumbs and passing through the dust which is returned for re-pelleting. Sizes of mesh are arranged according to the size of crumb required, but a suitable size is a No. 8 wire mesh on the top sieve and a No. 16 on the bottom. The Trigosifter, described on page 96, which combines a rotary and reciprocating action, is ideal for this type of work.

At present, the percentage of dust made in crumb manufacture is high and, in most conditions, may be as much as 30-40 per cent of the pellets being sized. Experience indicates that this may be reduced in future plants if, where possible, a bin is installed after the cooler with a feeder discharging to the crumbling rolls. This would allow the pellets more time to become colder and harder after pelleting but, more particularly, would enable them to be distributed evenly across the roll and without the intermittent feed caused by the constant stopping and starting of the cooler discharge mechanism of some types of machines.

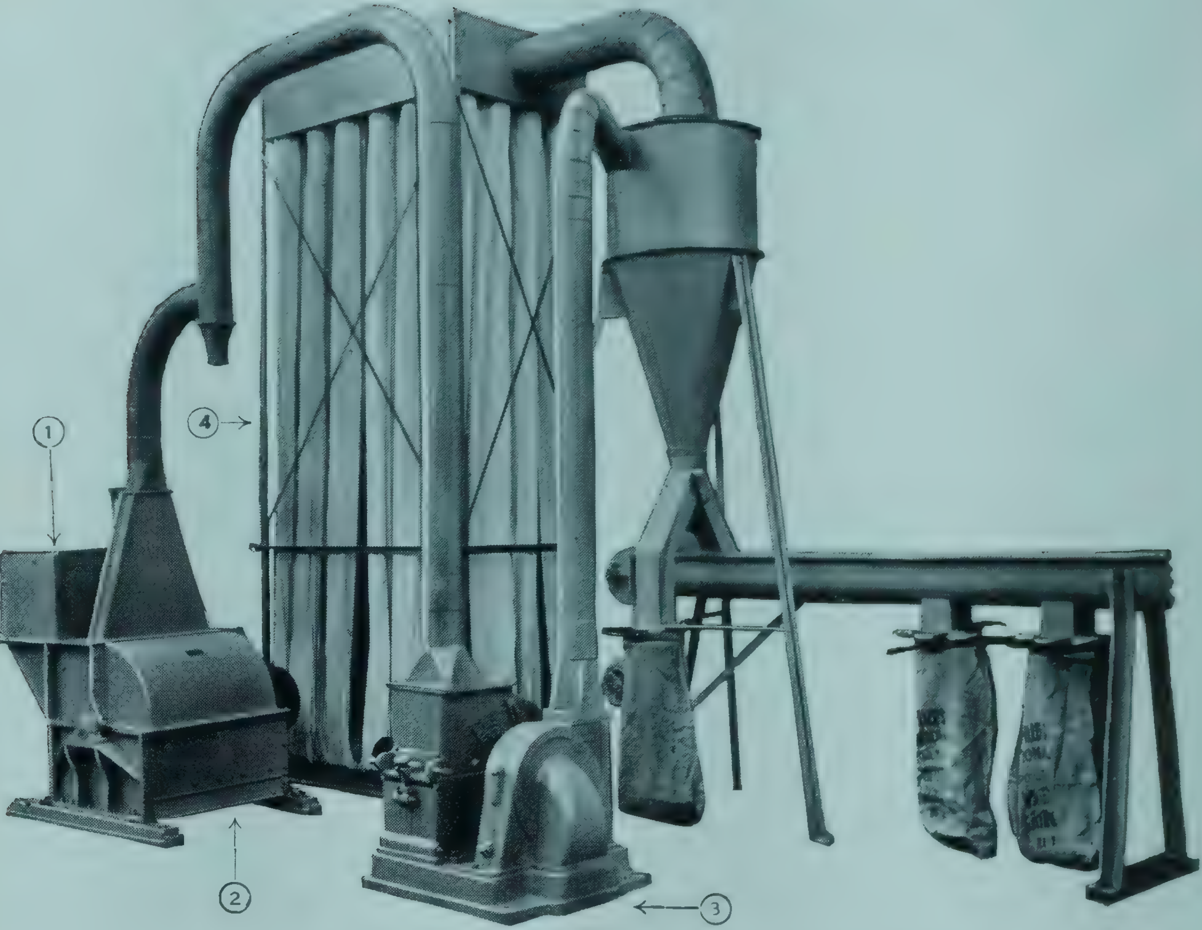


FIG. 154.—The Christy and Norris grass grinder plant.
1. Feed from grass dryer. 2. Pre-breaker. 3. Hammer mill. 4. Large dust collector.

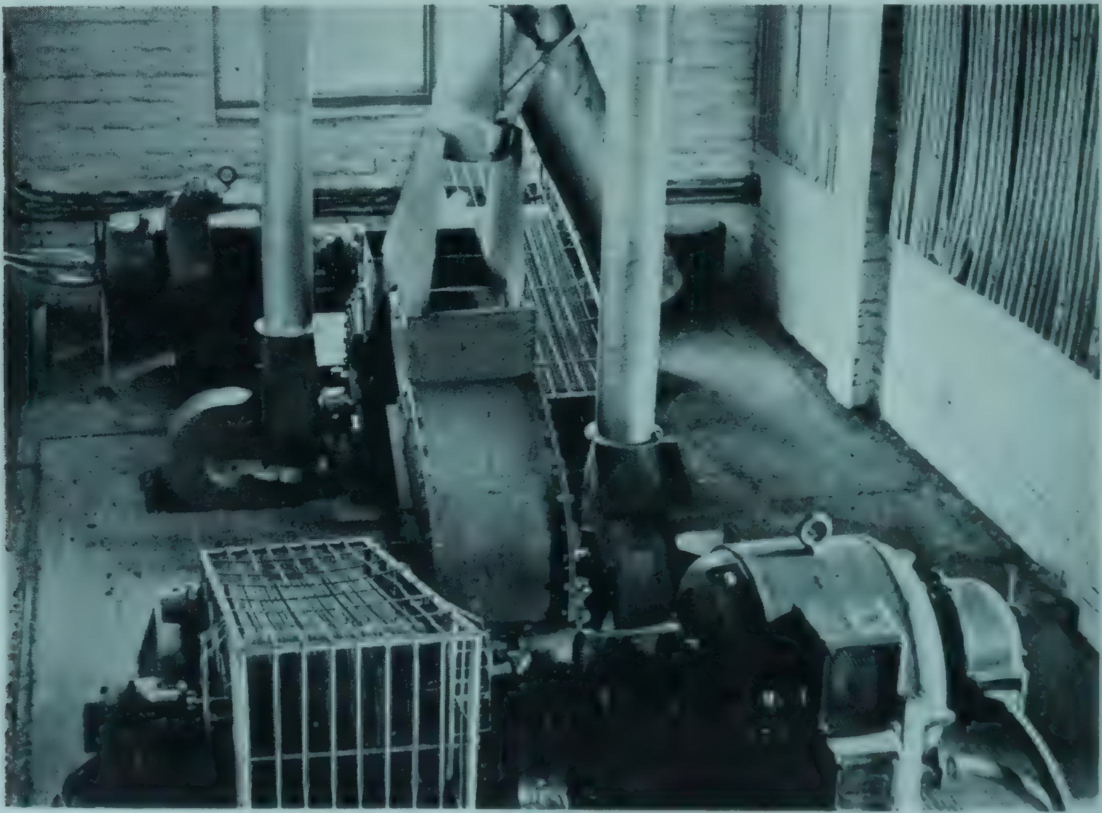


FIG. 155. Layout of grass grinders.

Chapter XVI

GRASS GRINDING AND CUBING

FOR feeding to cattle on the farm, dried grass may be compressed into bales and used without further treatment. The modern method is, however, to grind the grass as it leaves the dryer and to compress the meal into cubes or pellets. The meal may also be used in compound rations.

GRASS GRINDING

1. SPECIAL FEATURES OF GRASS GRINDERS

High speed percussion machines of the free swinging hammer type are used for grinding grass and green crops. For this purpose, they are often fitted with pre-breakers, partly, to break up the lengths of grass and, partly, to safeguard the grinder hammers from damage by metal, stones, sticks and other foreign matter, which are particularly liable to be found in farm products. Other features of grass grinders to be noted are the special large inlets and outlets, and the large inspection doors and dust collectors which are necessary by reason of the light and dusty nature of the material to be ground.

2. GRASS GRINDING PLANTS

Fig. 154 shows a photograph of a plant made by Christy & Norris Ltd. for grinding dried grass and green crops in which the large size of the inlets and other features can be seen. In this plant, the dried grass is fed direct to the pre-breaker from the dryer by a band or drag conveyor. The pre-breaker consists of revolving beaters or knives which are contained in a large frame and from which the broken grass is drawn away by suction to the main grinding chamber. This method leaves any metal or other heavy foreign matter in the bottom of the pre-breaker, thus safeguarding the hammers in the grinding chamber. The grinder screen for grass meal usually has a perforated mesh of 1½ to 2 mm. diameter holes.

A self-contained fan conveys the ground material pneumatically to a cyclone where it is bagged off either by a two-way spout or a worm with two bagging-off points, thus enabling the grass meal to be bagged off direct or conveyed to the cubing plant. The illustration shows the large textile sleeve dust collector, which is of the pressure filter type. Owing to the extremely dusty nature of dried grass, the cyclone and dust collector should preferably be placed outside the building. The grinder should be enclosed in a steel chamber to reduce insurance risks.

In a grass dryer of the conveyor type, which delivers the dried product from a continuous cross conveyor, the pre-breaker may be conveniently situated in a pit directly at the end of the conveyor. When the pre-breaker is fed by hand, however, it is normally placed at ground level. In smaller plants, the pre-breaker and the grinder can be driven from the same motor, but, in larger units, the pre-breaker and grinder may be driven by two separate motors. Fig. 155 shows another layout of grass grinders.

Freshly cut grass that is not wet with rain or dew normally contains about 80 per cent of water, which must be dried out to about 6 per cent before it can be ground, but the moisture content varies with the season, type of material, and the weather conditions. Lush spring grass will give a much lighter yield of dried material per ton of fresh product than grass cut during a mid-summer heat wave. The output of the dryer, therefore, varies, and this variation must be allowed for in the grinder. Similarly, the higher the moisture content of the dried material, the higher the power required for grinding, and, therefore, the lower the output. Christy & Norris Ltd. supply three sizes of grinders with output rates of from 3 cwt. to 1 ton per hour of dried material.

Fig. 156 shows a mobile grinding plant mounted on a lorry for grinding grass, lucerne, cereals and other farm crops. This type of plant may be used on large farms, particularly in countries such as Africa and Australia where very big distances have to be covered. A mobile dryer may be used in conjunction with the mobile grinding unit for artificially drying the crops, or they may be sun-dried in the field and then ground and bagged on the spot. The crops may thus be saved from deteriorating in the fields until required for local feeding or distribution.

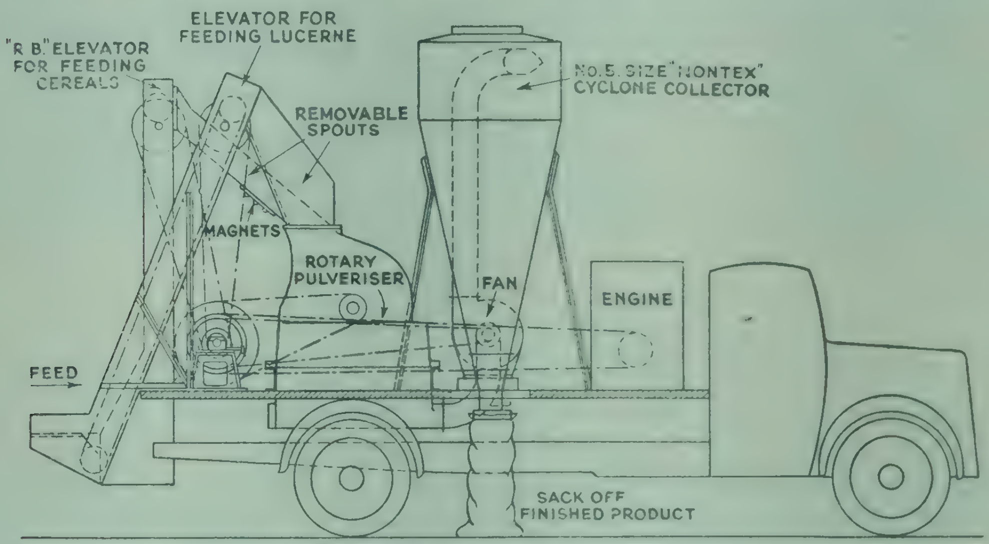

ELEVATOR FOR FEEDING LUCERNE
"R B." ELEVATOR FOR FEEDING CEREALS
No.5. SIZE "NONTEX" CYCLONE COLLECTOR
REMOVABLE SPOUTS
MAGNETS
ROTARY PULVERISER
FAN
ENGINE
FEED
SACK OFF FINISHED PRODUCT

FIG. 156.—Mobile grass and grain grinding plant.

Grass, lucerne and other green crops may be fed conveniently to the mobile grinding unit on to an inclined bar elevator direct to the grinder or dryer, or grain may be fed into an 'R.B.' link or bucket elevator. The spouts to the grinder are easily interchangeable for either purpose. The grinder shown in Fig. 156 is of the Barron Rotary Pulveriser type as described on page 118.

GRASS CUBING

1. Comparisons with Compound Cubing

The conditions encountered in grass cubing are more difficult than those in compound cubing; the main reason is the nature of the grass meal itself which is fibrous, bulky, abrasive and lacking in the oil that assists so much in the cubing of most meals.

When cubing different types of grasses and green crops, conditions vary considerably but generally the best results are obtained if a combination of steam and cold water is used. Steam alone or water alone are, however, used successfully, and many farmers and merchants avoid steam because it saves the expense of a boiler.

Grass meal takes time to assimilate moisture, and water should preferably be added as soon as possible after the grinder, although it is often more convenient to add it in the mixing section or kettle of the cubing machine. Steam appears to have most effect when introduced immediately before the die. The moisture content of the meal for cubing is increased to 12-14 per cent, and the temperature to about 120° F.

Except for the reason that grass has to be dried down to about 8 per cent moisture to enable it to be ground satisfactorily on hammer mills, the most practical and economical procedure would appear to be to regulate the moisture content and temperature of the grass on the dryer to bring it into the best condition for cubing. There may well be developments in this direction in the future in order to avoid the most uneconomical stage of drying grass, i.e. the extraction of the last few per cent of moisture, which has to be put in again for the cubing process.

Grass meal is lighter and bulkier than compound meals, weighing from 14 to 20 lb. per cubic ft. compared with 30 lb. per cubic ft. for compounds. Consequently, the output of grass cubes from a machine is only about a third of the output to be expected from compounds. Grass meal also has a very severe abrasive effect on dies, rolls, knives and other parts of machines with which it comes in contact. When processing grass meal, the normal life of these parts is only about a quarter of that experienced with compounds. This abrasive quality also tends to increase power consumption. To counteract this as much steam and/or water as possible should be used. Steam requirements are in the region of 100-200 lb. per hour with most machines.

In starting up a grass cubing machine, the oily meal and hard cubes procedure should be carried out as has been explained in the discussion of compounds. It is beneficial to follow this for a day or two with a small feed of almost dry grass meal so that the abrasive action of the meal thoroughly wears in the dies.

Working conditions on grass cubing plants can be very bad owing to the light and dusty nature of the meal. Special care should be taken, therefore, to see that all spouting, hoppers and conveyors are enclosed as much as possible, and that all joints and inspection hole covers are tight-fitting. In a single storey building, louvered vents should be arranged in the roof to clear the dusty atmosphere and, wherever possible, machines, elevators, and hoppers should be exhausted. In some Simon plants, air trunks may be arranged between the various points and the cooler fan.

2. GRASS CUBING PLANTS

The Templewood

Fig. 157 shows a small grass cubing plant installation by the Templewood Engineering Co. Ltd., having a capacity of about 5 cwt. per hour of cubes, which works in conjunction with a Templewood pre-breaking and grinding unit and a Mark 2 Conveyor Dryer. In this layout, the fresh grass is dried, ground and cubed without any intermediate handling.

The dried grass passes from the dryer to the pre-breaker and thence to the hammer mill from which it is blown to a cyclone. Provision is made for sacking off grass from the cyclone or it can be delivered by an inclined conveyor to the feed hopper of the cuber. After cubing, the cubes are then sieved over a screen. The complete installation occupies a space of 60 ft. × 45 ft.

The ‘ Sizer ’ All in One

Fig. 158 shows a grass cubing installation by Richard Sizer Ltd. of similar capacity to that of the Templewood. The ‘ Sizer ’ All in One is supplied in one frame for a single storey building. This type of plant may also be used for compound purposes and, although the unit in Fig. 158 incorporates the ‘ Sizer ’ machine, units of different sizes may be supplied with other cubing machines made by Richard Sizer Ltd.

In Fig. 158 the ground meal may be fed from the grinder cyclone or from bags into the mixer and elevated to a bin which delivers by means of a shoe feeder to the Turbulator of the cubing machine. After being mixed with water or molasses and passing through the machine, the cubes or pellets are elevated to the cooler and pass over a screen before cooling. The dust from the screen is bagged off and can be returned to the cubing machine. The plant is accessible and easy to operate.

In larger units, which make grass cubes as well as compound cubes or pellets, the ingredients may be tipped into an elevator feeding the mixer. After mixing, the batch then passes over a sieve, to extract rubble, into the same elevator. The elevator has a forked delivery spout and valve so that the mixed batch may be turned over into a bin.

The bin is then discharged by a shoe feeder into another elevator which delivers over a magnet into the cubing machine. In this way, the contents of the bin keep the cubing machine in continuous operation while another batch is being prepared in the mixer. The cubes and pellets are then elevated to the cooler in the same way as in the smaller unit. This plant is fully described in Chapter XIII.

Master Model Plant

Figs. 159A and B show a flow diagram and layout of a larger capacity grass cubing plant by Henry Simon Ltd. which is installed in a single storey building in one frame. The plant is compact and is only 21 ft. 5 in. long, 15 ft. 3 in. high and 8 ft. 9 in. wide. It has a capacity varying between 12-18 cwt. per hour of $\frac{3}{8}$ in. or $\frac{1}{2}$ in. grass cubes, according to the quality of the grass; it incorporates one Master Model Californian press.

In this plant, the ground meal from the hammer mill is blown into a cyclone which delivers to a side hopper-fed, vertical mixer. The mixer is, in fact, a reserve bin for ground material for the cubing machine, but there is the further advantage that it can be used for mixing various kinds of grass

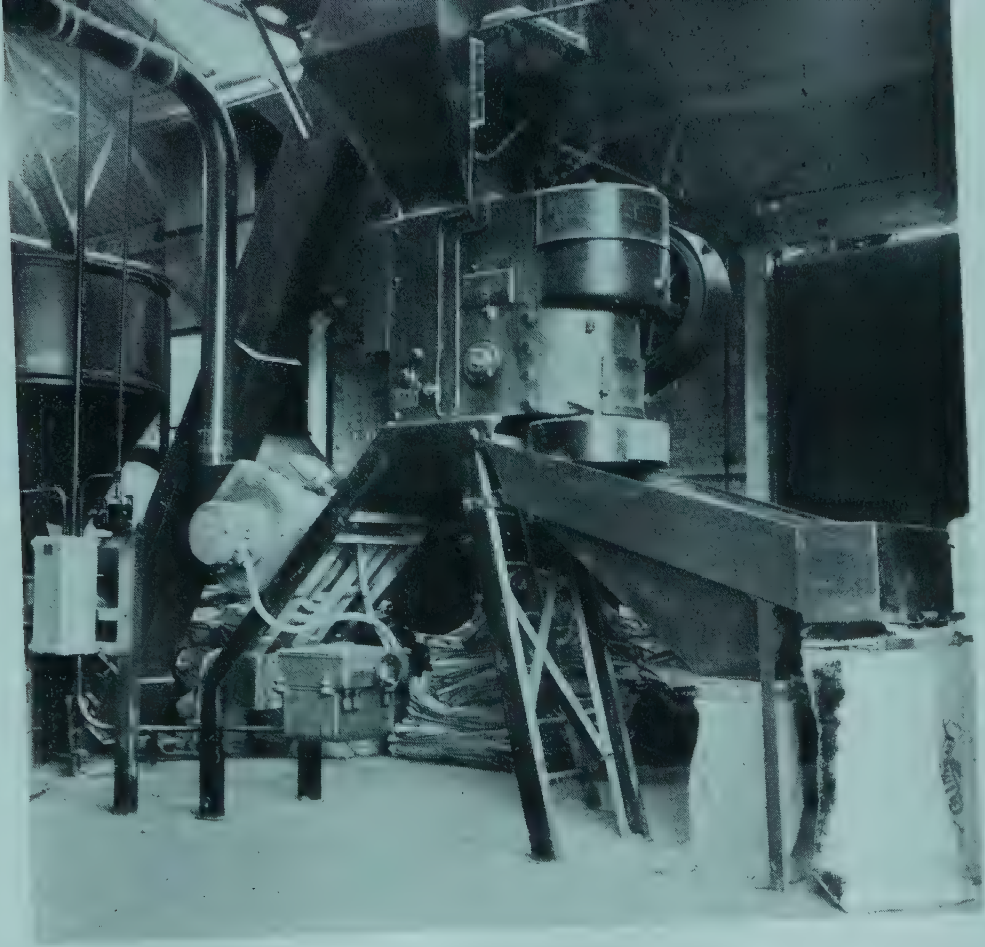
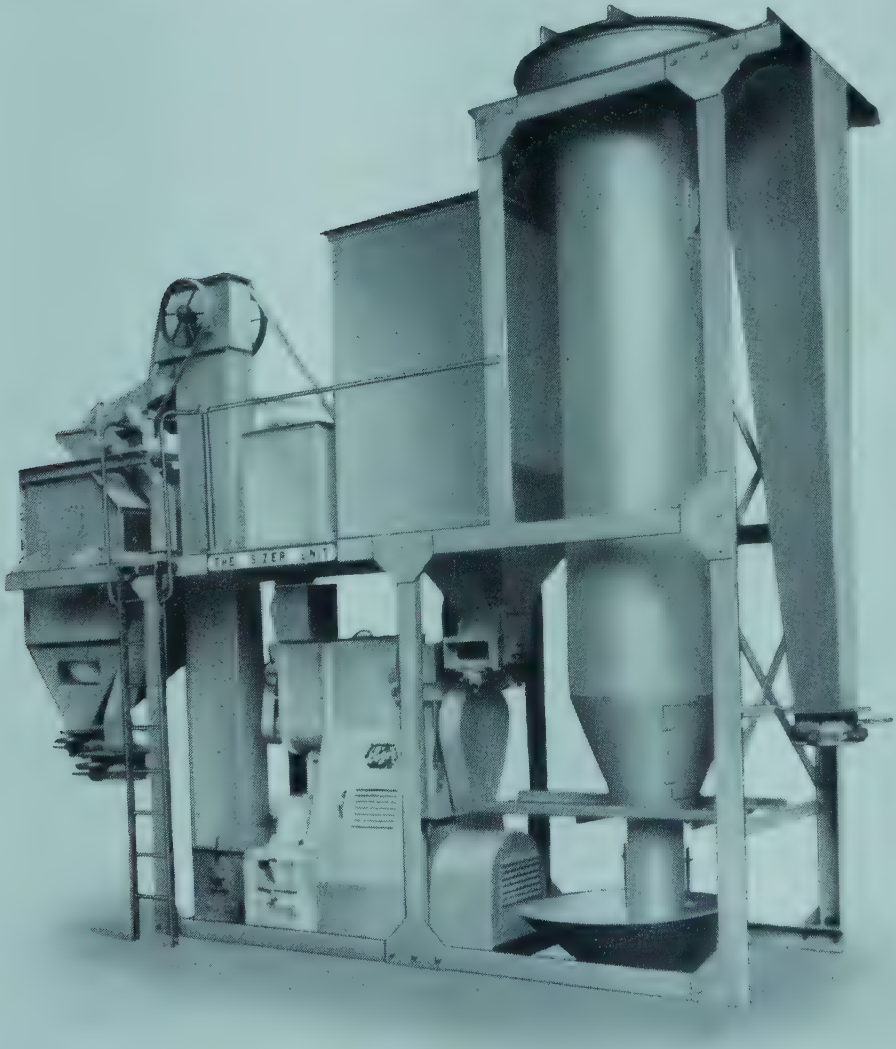


FIG. 157.—Templewood grass cubing plant.



meals, and for adding water which, if mixed at this point, is thoroughly absorbed by the meal before it reaches the cubing machine. In addition, the side hopper feed and vertical worm take the place of an elevator and the worm assists the discharging and free running of the grass meal into the first R.B. elevator-conveyor feeding the cubing machine. An overflow is led over a magnet above the cubing machine back through a short worm to the same R.B. elevator-conveyor.

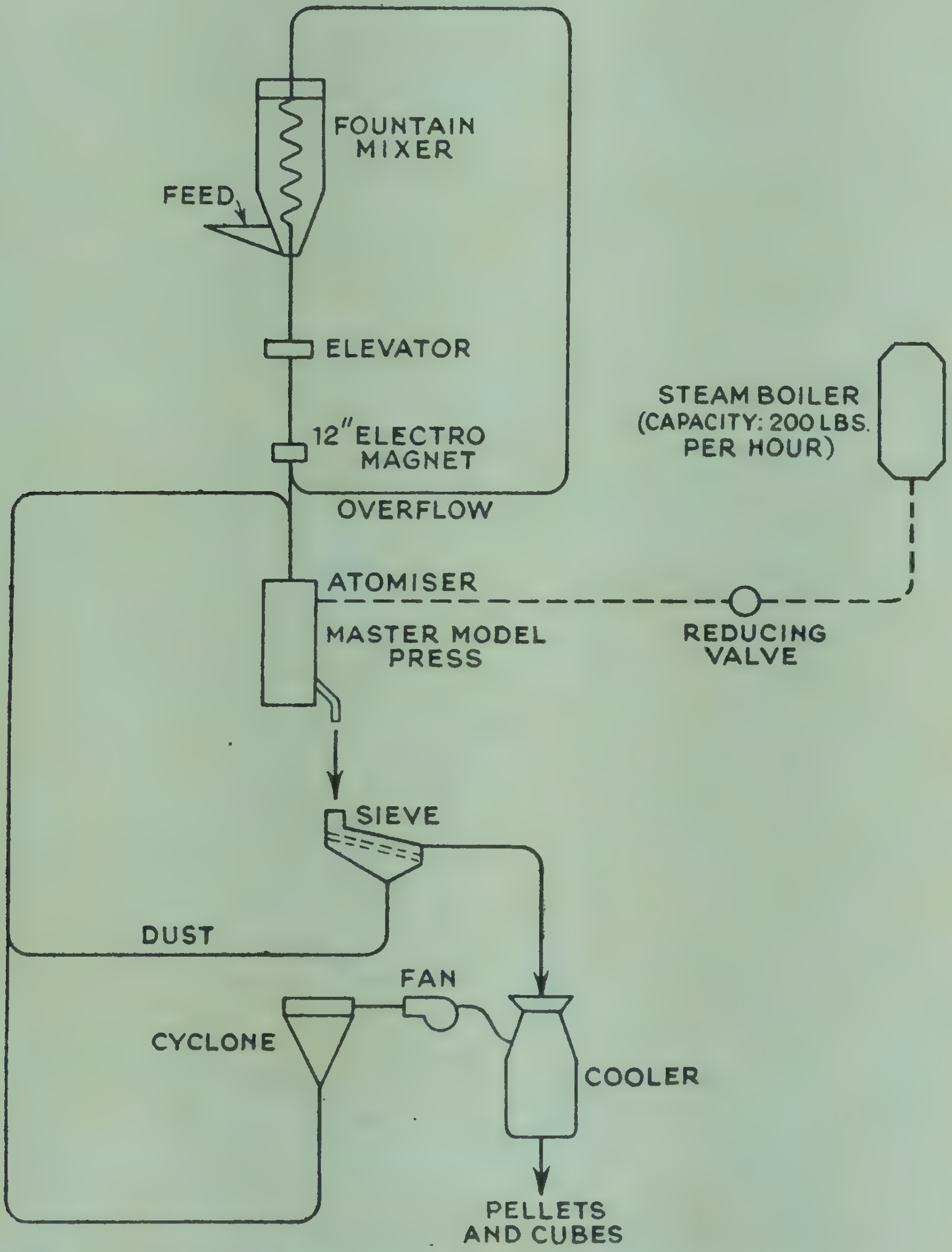
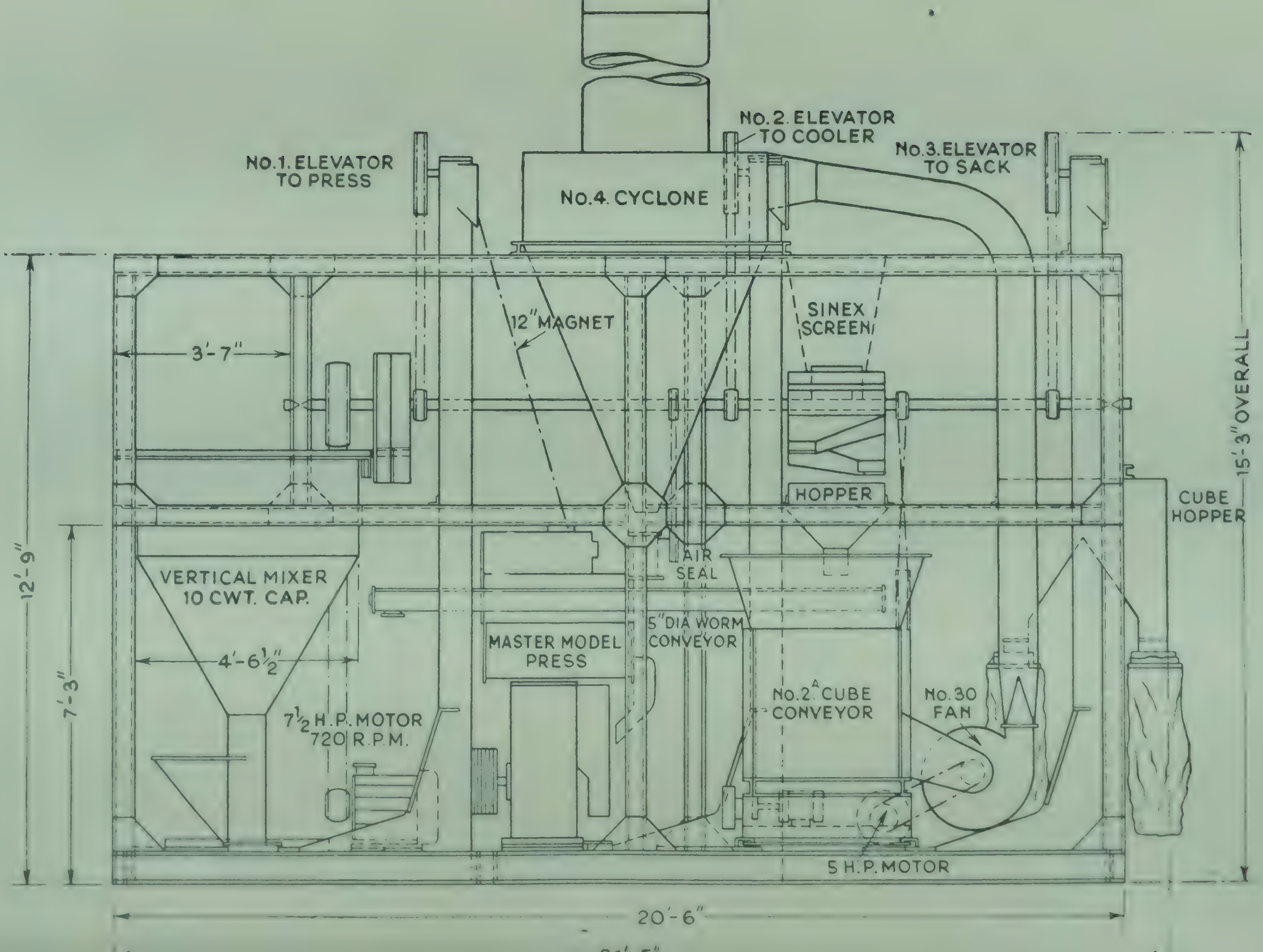

FOUNTAIN MIXER
FEED
ELEVATOR
12″ ELECTRO MAGNET
OVERFLOW
STEAM BOILER (CAPACITY: 200 LBS. PER HOUR)
ATOMISER
MASTER MODEL PRESS
REDUCING VALVE
SIEVE
DUST
FAN
CYCLONE
COOLER
PELLETS AND CUBES

FIG. 159A.—Simon grass cubing plant, suitable for single storey building.

After leaving the cubing machine, the cubes or pellets are elevated to a sieve, which extracts dust and chippings and, finally, they pass through the gravity cooler and are elevated to the bagging off hopper.



No. 1. ELEVATOR TO PRESS
No. 4. CYCLONE
No. 2. ELEVATOR TO COOLER
No. 3. ELEVATOR TO SACK
15'-3" OVERALL
12" MAGNET
SINEX SCREEN
3'-7"
HOPPER
CUBE HOPPER
12'-9"
7'-3"
VERTICAL MIXER 10 CWT. CAP.
AIR SEAL
5" DIA WORM CONVEYOR
MASTER MODEL PRESS
4'-6½"
No. 2A CUBE CONVEYOR
No. 30 FAN
7½ H.P. MOTOR 720 R.P.M.
5 H.P. MOTOR
20'-6"

Combined Grass and Compound Cubing Plant

Fig. 160 shows a diagram of a larger installation by Henry Simon Ltd. suitable for either grass or compounds and having a minimum output of 1 ton 4 cwt. per hour of $\frac{1}{2}$ in. grass cubes or 4 tons per hour of $\frac{1}{2}$ in. compound cubes. The plant is arranged in a single storey building.

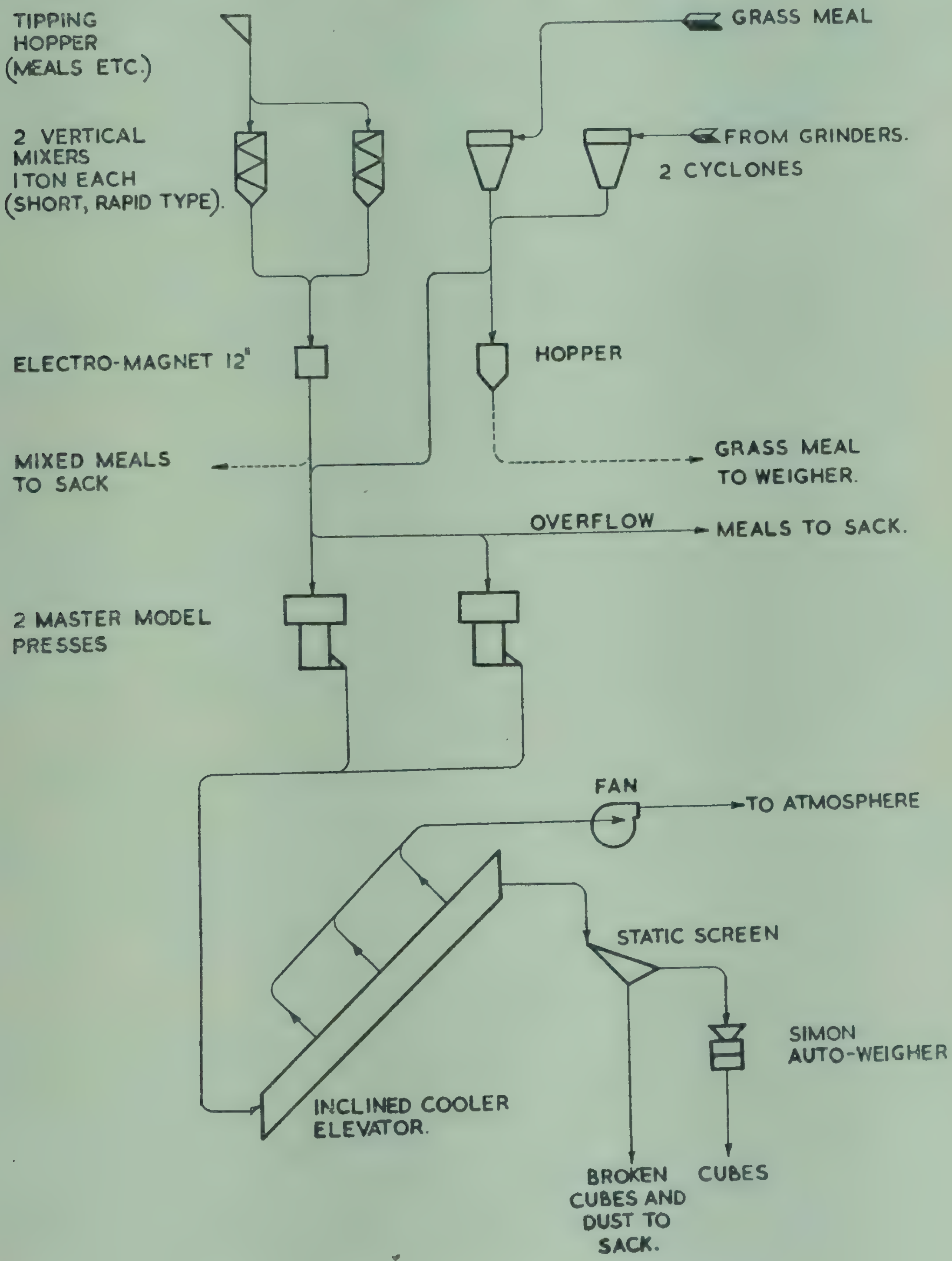

TIPPING HOPPER (MEALS ETC.)
GRASS MEAL
FROM GRINDERS.
2 VERTICAL MIXERS I TON EACH (SHORT, RAPID TYPE).
2 CYCLONES
ELECTRO-MAGNET 12"
HOPPER
MIXED MEALS TO SACK
GRASS MEAL TO WEIGHER.
OVERFLOW
MEALS TO SACK.
2 MASTER MODEL PRESSES
FAN
TO ATMOSPHERE
STATIC SCREEN
SIMON AUTO-WEIGHER
INCLINED COOLER ELEVATOR.
BROKEN CUBES AND DUST TO SACK.
CUBES

FIG. 160.—Combined grass and compound cubing plant.

The ground grass or other meal is delivered from Barron Rotary Pulverisers to two cyclones which, by means of a worm conveyor, feed either a small hopper or the two Master Model Californian press cubing machines. Grass or other meals are sacked off from the hopper.

The compound ingredients are mixed in two vertical Barron mixers of 1 ton capacity each, the mixture being either sacked off as compound meal or sent over a magnet to the same worm conveyor feeding the cubing machines. Further flexibility is provided by the overflow from the worm conveyor, which enables compound or grass meals to be packed off at this point and also ensures a regular feed to the cubing machines.

After passing through the cubing machines, the cubes or pellets are gently conveyed and cooled by an inclined conveyor cooler which is suitable for a single storey building. This machine minimises cube breakage which is liable to be particularly severe when grass cubes are handled by bucket or link elevators. Also, as the cooler elevates the cubes to sacking off height, the expense of an elevator is saved.

The cooler consists of shallow, perforated buckets linked together to form an endless chain and attached by rods to side rollers; these run at about 60 ft. per minute on inclined side channels over top and bottom sprockets. The angle of incline is in the region of 60° and the size of the buckets can be arranged to suit the output required. The drive may be arranged from a countershaft or built-in motor.

Air is drawn through the perforated buckets by a fan. A series of pipes fitted with valves between the fan and the machine enables the operator to control the amount of cooling at three points up the length of the conveyor. A certain amount of dust, which passes through the perforated buckets, is collected at the bottom of the conveyor, but a sieve is provided before the bagging off hopper to extract dust and chippings. This cooler is not advocated in preference to the gravity type; it is only used when there is insufficient height available to install the gravity machine.

Chapter XVII

CEREAL FLAKING

COOKED, flaked maize is a popular feeding stuff, but for many years production has been limited by the supply position of the imported grain. At present, production is mainly in the hands of large port provender millers because the process is elaborate and costly and generally there is much more interest in compound milling, particularly amongst smaller millers. Consequently, there has been little technical advance in recent years in the flaking process or in the machines employed in it.

One development has been that other cereals, such as barley, beans and peas, are becoming more popular in flaked form and, as they can be processed by the same plant, they help to keep flaking plants employed when there is a shortage of maize. To this extent, and in view of the present improvement in the supply position of maize, there is now some renewal of interest in cereal flaking.

MAIZE FLAKING

(1) GENERAL DESCRIPTION OF PLANT

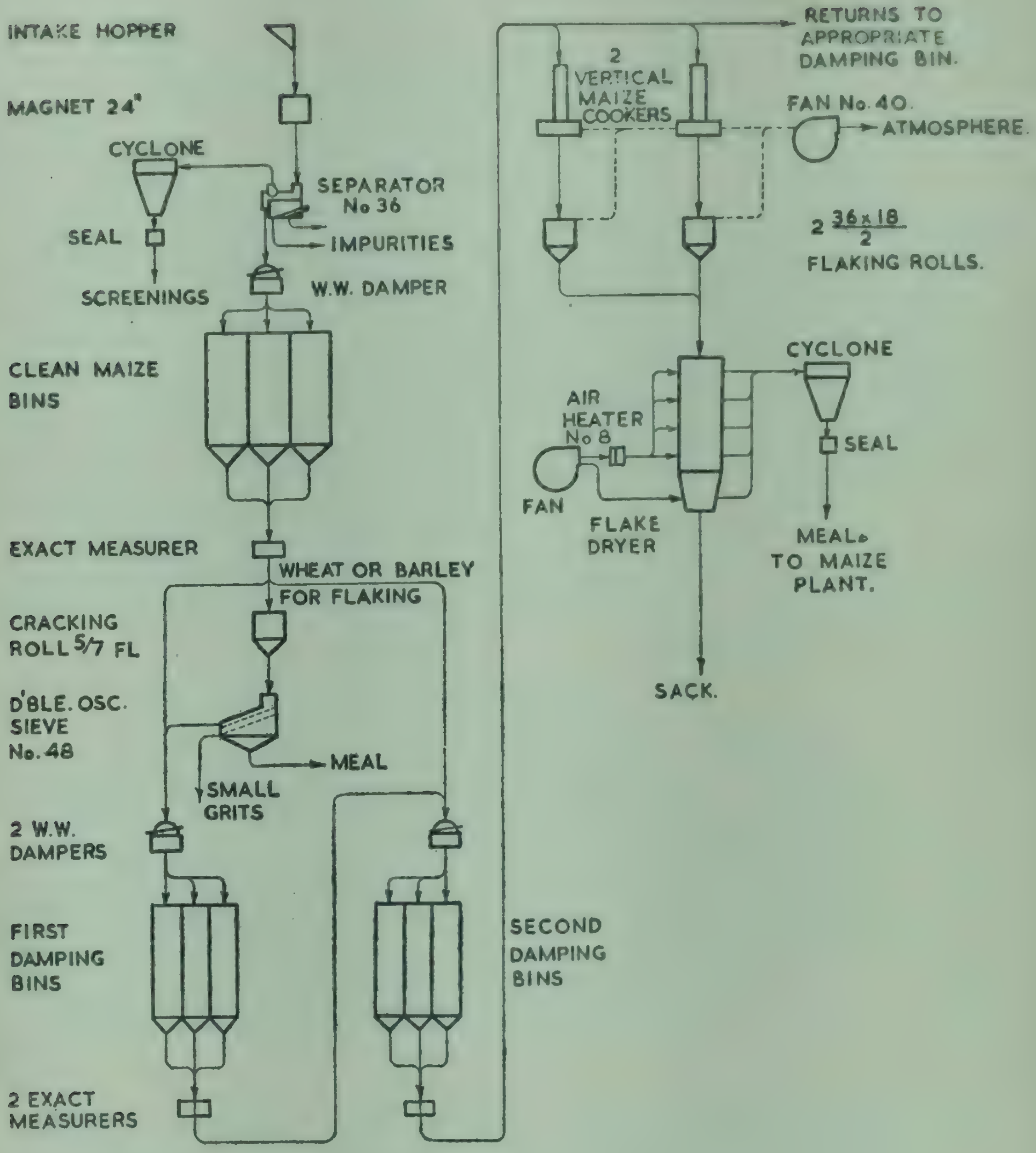
Fig. 161 shows a flow diagram of a maize flaking plant having a capacity of 2 tons per hour of flaked maize. The raw maize is first given a rough preliminary cleaning and is then cracked over fluted rollers, from which the meal is removed by a sieve. The cracked grain is conditioned by allowing water to assimilate with it in conditioning bins until the moisture content is raised to approximately 20 per cent. It is then cooked or gelatinised and flaked on heavy duty 18 in. diameter rollermills, the flakes being finally dried to a moisture content of 15-16 per cent and cooled before packing.

(2) PRELIMINARY CLEANING

This may be carried out by any kind of milling or warehouse separator to remove large impurities and dust from the whole grain. The top screen of the separator should have a mesh of approximately 28 × 10 mm. holes for over-tailing the large impurities, and the bottom screen a 2 mm. round hole mesh for over-tailing the maize, the throughs of the bottom screen being dust.

(3) CRACKING OR CUTTING

Maize can either be flaked whole or cut into two or three pieces by a rollermill, the top and bottom rolls being fluted with five and seven flutes to the inch respectively and running sharp to sharp with a differential of 2½ to 1. The speed of the driving roll should be 300 r.p.m. Corn cutters may also be used for this purpose and, when the knives are sharp, they make less meal than rollermills, but the latter are more economical. The knives of corn cutters have to be sharpened frequently and their maintenance costs are heavier.


INTAKE HOPPER
MAGNET 24"
CYCLONE
SEPARATOR No 36
SEAL
IMPURITIES
SCREENINGS
W.W. DAMPER
CLEAN MAIZE BINS
EXACT MEASURER
WHEAT OR BARLEY FOR FLAKING
CRACKING ROLL 5/7 FL
D'BLE. OSC. SIEVE No. 48
MEAL
SMALL GRITS
2 W.W. DAMPERS
FIRST DAMPING BINS
SECOND DAMPING BINS
2 EXACT MEASURERS
RETURNS TO APPROPRIATE DAMPING BIN.
2 VERTICAL MAIZE COOKERS
FAN No. 40.
ATMOSPHERE.
2 36 x 18 / 2 FLAKING ROLLS.
CYCLONE
AIR HEATER No 8
SEAL
FAN
FLAKE DRYER
MEAL TO MAIZE PLANT.
SACK.

MAIZE FLAKING PLANT

CAPACITY:-1 TON PER HOUR.

FIG. 161.

A double-deck, oscillating sieve or a reel may be arranged to make two separations of the cracked maize. The overtails of the coarse cover, which has a 7 mm. diameter round hole mesh, return to the roll. The overtails of the fine cover, which has a $1\frac{1}{2}$ mm. round hole mesh, are the sized grits ready for damping and flaking, and the throughs of the fine cover are meal containing the germ. This germ meal, which is rich in oil and constitutes about 5 per cent of the maize, may be sold as a separate product or mixed back into the maize flakes or meal. It is, however, usually sufficient to make one separation of maize with a single deck fine sieve with 1½ mm. round hole mesh as shown in Fig. 161.

The cracking of maize before flaking is economical because, compared with the flaking of the whole grain, it results in a more thorough cooking and reduces steam consumption and conditioning time. The moisture permeates more easily and quickly into the broken grain through the much greater surface exposed and the horny, relatively impervious skin does not obstruct its entry. Consequently, only two sets of conditioning bins are needed instead of three for whole maize and a more simple plant layout becomes possible.

Another advantage of cracking is that the extraction of the germ meal makes the plant much cleaner to operate because the germ, when steamed and pasty, clogs machines, spouts and elevators. Also, a flake of cleaner appearance is produced. On the other hand, the extraction of the germ robs the flake of its valuable oil content, but, as already explained, the germ meal can be mixed back into the flakes without going through the plant. The best method is to have a small hopper and shoe feeder to mix the germ meal into the flakes after the flaking roll.

Some millers, however, prefer the flaking of whole maize because it makes a broader flake, avoids making germ meal and obviates the need for a cracking roll. On the whole, the cracking method as illustrated in Fig 161 offers more advantages.

(4) CONDITIONING

The conditioning process varies according to the country of origin, time of season and quality of the grain. An average natural moisture content of maize is in the neighbourhood of 12-13 per cent, although the figure may be as much as 3 per cent lower for old crop maize and 3 per cent higher for new crop.

It is usual to add about 6-8 per cent of water in the conditioning process according to the natural moisture content. Also, if the damping is done in stages, better absorption and more uniform distribution of the water throughout the grain is obtained.

Tests have shown that cracked maize quickly absorbs about 2 per cent of water and, if the grain is immersed for 1 minute, this quantity is increased to 3 per cent, a further 2½ per cent being carried on the surface. A rinsing worm is, therefore, capable of adding about 5-6 per cent in one damping. However, as it is better to add the moisture in stages, water wheel dampers are used because they do not subject the grain to so long an immersion in one stage.

Tests have shown that, with cracked maize, this moisture can be absorbed in about 17 hours, with a further 7 hours, making a total of 24 hours, to allow it to be evenly distributed throughout the grain. In the case of whole maize, another damping and a further 12 hours, making a total of 36 hours, is usually necessary.

Practical experience, however, has proved that even better results are obtained if a much longer conditioning period is given to the grain with a preliminary damping of up to 2 per cent of water. The ideal, therefore, if it can be arranged, is to damp the maize on entering the silo or storage bins up to this amount and to allow it to condition for about a week. Once the grain has been subjected to the heavier dampings of 5-6 per cent in the conditioning bins, longer periods than those indicated above must be avoided or the grain will tend to get sour and cake in the bins.

If the pre-damping method is adopted, the conditioning period for the last damping may be shorter and the third damping in the conditioning bins for whole maize can be eliminated. In any case, the conditioning bins must be emptied when stopping the plant over the week-end.

Damping or conditioning bins are sometimes arranged in a series of three, as in Fig. 161, so that one bin is emptying, one filling and one standing in rotation, but, provided cracking is carried out, two bins for each damping are quite satisfactory. Precautions should be taken to avoid grading in the bins because, if it occurs, and particularly when flaking whole maize, smaller flakes will be made each time a bin is nearly empty. Grading may be avoided by an inverted pyramid in the bin bottom so that the grain empties evenly from all sides. Alternatively, the bin may be arranged with four outlets.

(5) COOKING

The grits are cooked by vertical cookers, which inject live steam at various levels into the mass of material. It is important that the cookers should be kept full to ensure uniform cooking, and to prevent steam passing up the feed spouts, thereby causing sweating and, possibly, choking. To ensure that they are full, an overflow spout must be arranged to pass the surplus grits from the feeds to the cookers back to the conditioning bins.

The water added during cooking is usually in the region of 3 per cent, bringing the moisture content of the grits up to an average of 23 per cent. The steam pressure used is usually about 30-40 lb. per square in., but some variation is necessary according to conditions. When starting up, the first grits leaving the cooker will not be sufficiently softened for flaking and provision should be made for returning them to the bins.

(6) FLAKING

It is important that the flaking rolls should be situated immediately under the cooker so that the grits, which leave the cookers in a hot and steaming condition at about 212° F., flow directly into them. The rollers are of the two-roll, horizontal type as described on page 217. Where whole maize is flaked, the roll surfaces should have an occasional flute to grip the grain and prevent it from backing up in the nip of the rolls. Approximately 2 per cent of moisture is lost during the passage of grits through the rolls. The rolls should be adjusted so that the flakes are as thin and broad as possible because this not only improves their appearance but makes them easier to dry. Both cookers and rolls should be thoroughly exhausted to prevent ‘ sweating ’ of machines and condensation inside the mill.

(7) Drying and Cooling

Drying and cooling may be carried out by the Cascade Dryer, the Thermo-Pneumatic system or band dryers as described on pages 218-219. All these machines surround the flakes with hot and cold air. The flakes are dried down to a final moisture content of 15-16 per cent, varying slightly in summer and winter, and cooled to atmospheric temperature.

(8) Packing of Flaked Maize

Cooked flaked maize is packed in large porous bags to allow air circulation, otherwise the flakes tend to become lumpy and mouldy. Bags may be as large as 60 in. × 30 in. per cwt. when thin large flakes are made from the whole grain, but they are usually 56 in. × 28 in. when smaller and thicker flakes are made from maize grits. Flakes should be tightly packed to prevent breakage and, therefore, mechanical possers are advantageous as shown in Fig. 188. Possing does not break the flakes.

(9) Summary of Steam Requirements, Pressures, Temperatures, Power and Moisture Contents

(*a*) *Steam consumption per ton of Flaked Maize*

Cooking	200-250 lb. per hour.
Drying	400-450 lb. per hour.
Total	600-700 lb. per hour.

(*b*) *Steam Pressures*

Cooking	30-40 lb. per sq. in.
Air heater	70-80 lb. per sq. in.

(*c*) *Temperatures*

Grits leaving cookers	212° F.
Air heater	280° F.
Air leaving heater	240° F.

(*d*) *Power*

50-60 h.p. for 1 ton per hour plant subject to variation if whole or cracked maize is flaked.

(*e*) *Moisture Contents* (Carter-Simon oven working at 155° C. for 15 minutes)

	per cent
Natural moisture content	12-13
Grits after pre-damping	14-15
Grits after	
1st main damping	16-17
2nd main damping	19-20
Cooking	22-23
Flakes entering dryer	20-21
Dried flakes	15-16

The above figures are only approximate as they vary according to the type of maize, country of origin, and time of season.

Barley, Bean, Pea and Wheat Flaking

These cereals are flaked on the same plant as maize, the only difference being that they are almost always flaked whole. Also, because the natural moisture content of these cereals is usually higher, about 2 or 3 per cent less moisture is normally added, although conditions may vary considerably with different parcels of grain. Heavy pressure on the flaking rolls is not necessary and lighter rolls of 10 in. diameter may be used. The flakes are more brittle than maize flakes and, when drying and cooling, require gentler handling.

Referring to Fig. 161, a suitable flow for these cereals would be from the main bins direct to the second damping bins and water wheel, thereby by-passing the cracking rolls and the first damping system.

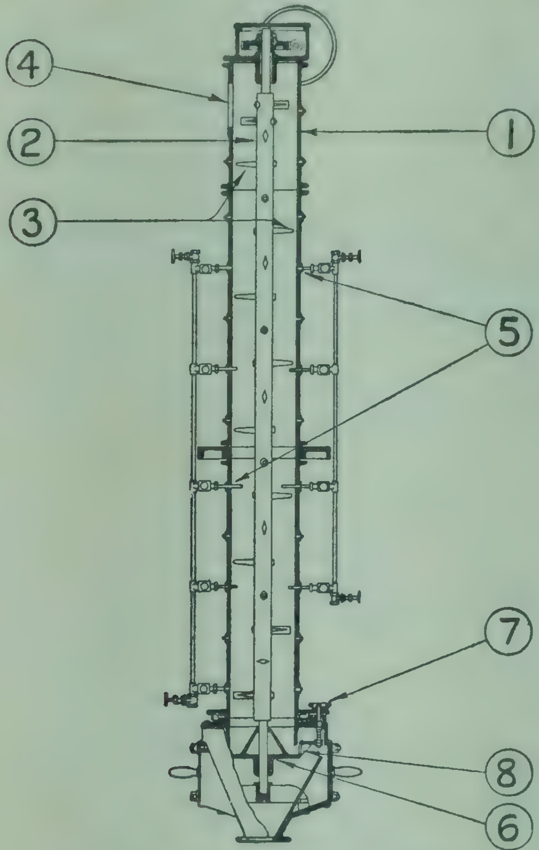


Fig. 162.—Vertical cooker.

1. Cooking tube. 2. Revolving spindle. 3. Agitators. 4. Feed inlet. 5. Steam valves. 6. Rotating circular plate. 7. Adjusting handwheel for plate. 8. Discharge gap for grain regulated by plate.

CEREAL FLAKING MACHINES

(1) Cookers

Fig. 162 shows a vertical cooker manufactured by E. R. & F. Turner Ltd., which is used for the cooking or gelatinisation of maize, or other cereals. The machine consists of a number of cast iron sections, bolted together, and standing from 8 to 13 ft. high according to capacity. A slowly revolving spindle, fitted with paddles and driven at the top by a worm gear, is arranged in the centre of the vertical cast iron cylinder or cooking tube. A number of live steam jets controlled by needle valves are fitted externally down each side of the cylinder.

The cereal is fed in at the top and travels down in a solid mass as the live steam is injected into it. The rotating paddles break up the mass, thereby allowing the steam to penetrate evenly throughout it. An adjustable outlet gate consisting of a rotating circular plate which is raised or lowered by a handwheel, regulates the rate at which the grain passes through the machine. Covers are provided at the bottom of the machine for inspection purposes.

(2) Cereal Flaking Rolls

A Turner flaking roller mill containing two rolls is shown in Figs. 163 A and B.

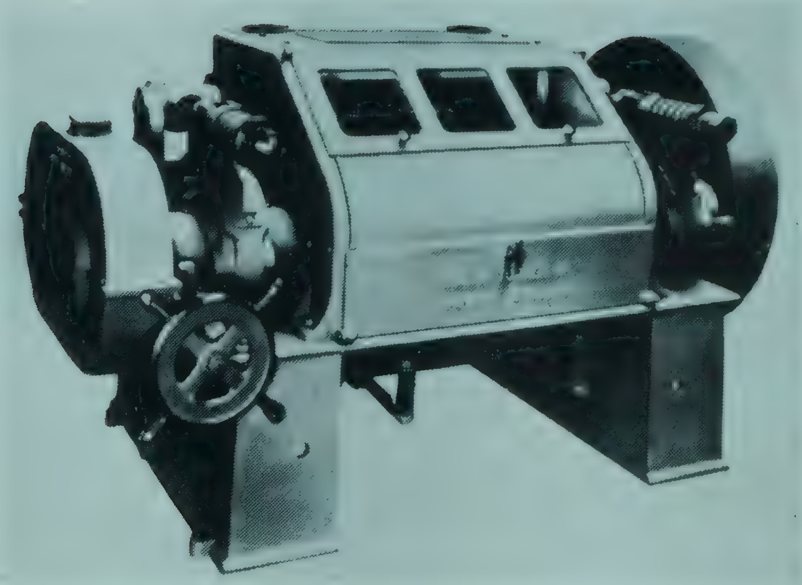


FIG. 163B.—Turner flaking roll.

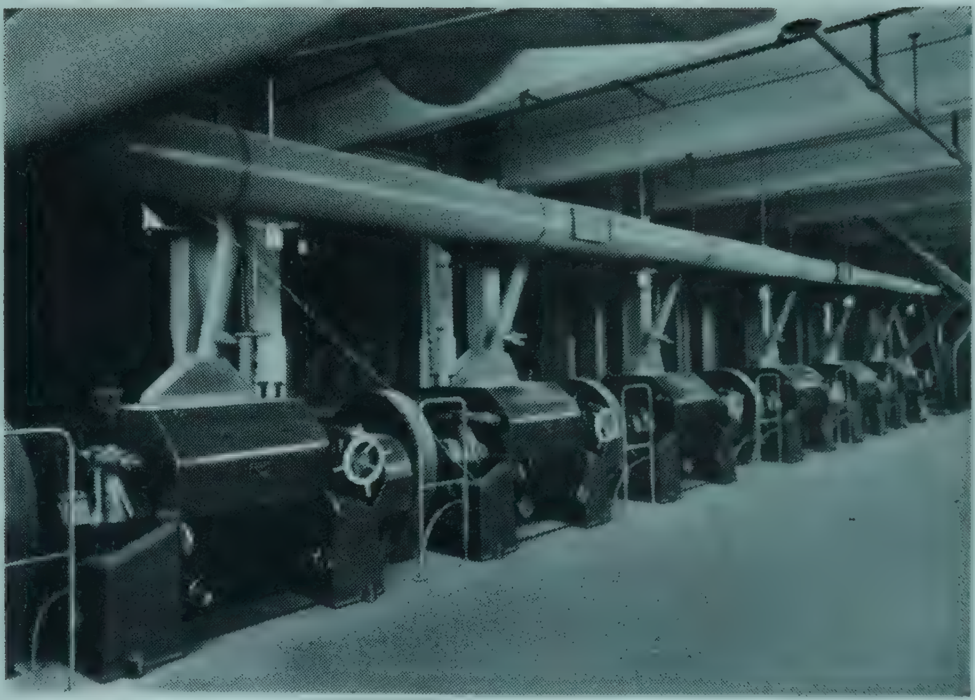


FIG. 164.—A line of Simon flaking rolls in a large mill.

The cooked grain from the cooker is fed through a grid, which prevents large extraneous matter getting into the rolls, on to a shaker tray. The tray, driven by an eccentric shaft and fitted with a clutch so that the feed can be instantly stopped or started as required, delivers the cooked cereal evenly into the nip of the rolls.

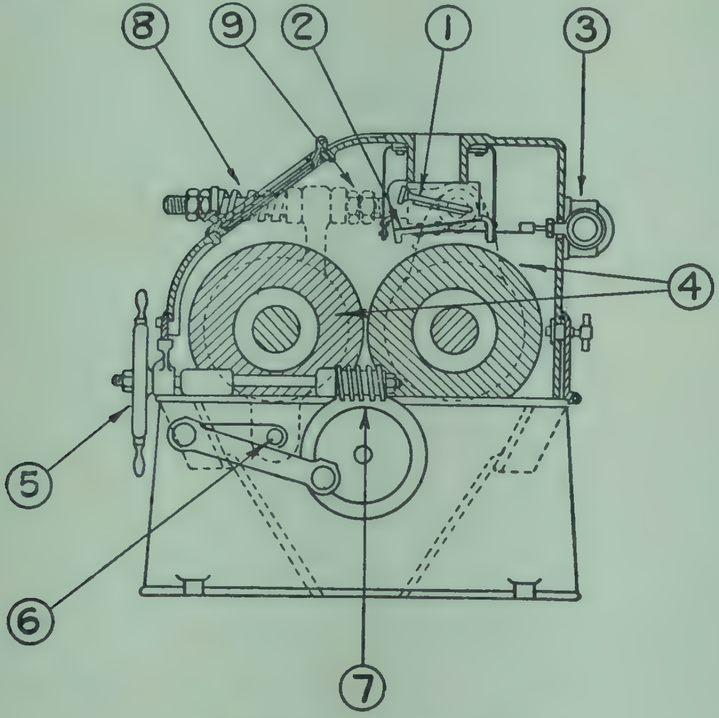


FIG. 163A.—Turner flaking roll.

1. Grid. 2. Shaker tray. 3. Eccentric. 4. Cast iron rolls. 5. Roll adjusting handwheel. 6. Eccentric shaft for roll adjustment. 7. Worm gear. 8. Pressure springs. 9. Adjusting nuts.

The rolls are 18 in. in diameter and are specially heavy; they run at equal speeds at 150 r.p.m. so that they flatten the maize into flakes without any grinding action, their surfaces being slightly roughened to enable them to grip the smooth coated grain. Both rolls are mounted in heavy, self-oiling bearings, the front roll bearings being simultaneously adjustable by a handwheel according to the pressure required; the handwheel controls an eccentric shaft passing through the bearing housings, which is connected by links to a worm gear on the handwheel spindle. Pressure springs fitted above the rolls allow them to open if any hard foreign body passes into the nip. The handwheel is fitted with a stop so that, if required, the adjustment can be slacked off and returned immediately to its former setting, thus eliminating the necessity for a throw-out lever. Steel scrapers are fitted to the rolls, the pressure being adjusted by springs. Exhaust connections are provided at both sides of the machine.

The cereal flaking roll (Fig. 164) manufactured by Henry Simon Ltd., is similar in general arrangement to the Turner machine. The principal difference is in the design of the gear for adjusting the pressure between the rolls. Unlike the Turner machine, the Simon movable roll is adjusted at each end by a separate handwheel and worm gear. A scale and pointer fitted on the worm gear casing shows the relative position of the rolls.

Fig. 164 shows a group of Simon flaking rolls installed in a modern provender mill.

(3) Maize Flake Dryers

(a) *The 'Cascade' Dryer*

The Cascade flake dryer made by E. R. & F. Turner Ltd. (Fig. 165), is designed for the drying and cooling of flakes after they have passed through the flaking rolls. The flakes are evenly distributed over the width of the dryer by the feed spreading spout and enter the first drying section through a rotary air lock, which prevents air blowing up the spout. The first drying section consists of a slowly revolving drum divided into a series of pockets which contain the flakes. The bottom of each pocket is perforated so that hot air, blown into the centre of the drum by a fan, passes through the flakes and pockets and escapes from the machine through an outlet in the position shown in Fig. 164. The revolving drum carries the flakes round and delivers them to the second drying section where the same process takes place. Several drying sections may be used for larger capacity machines.

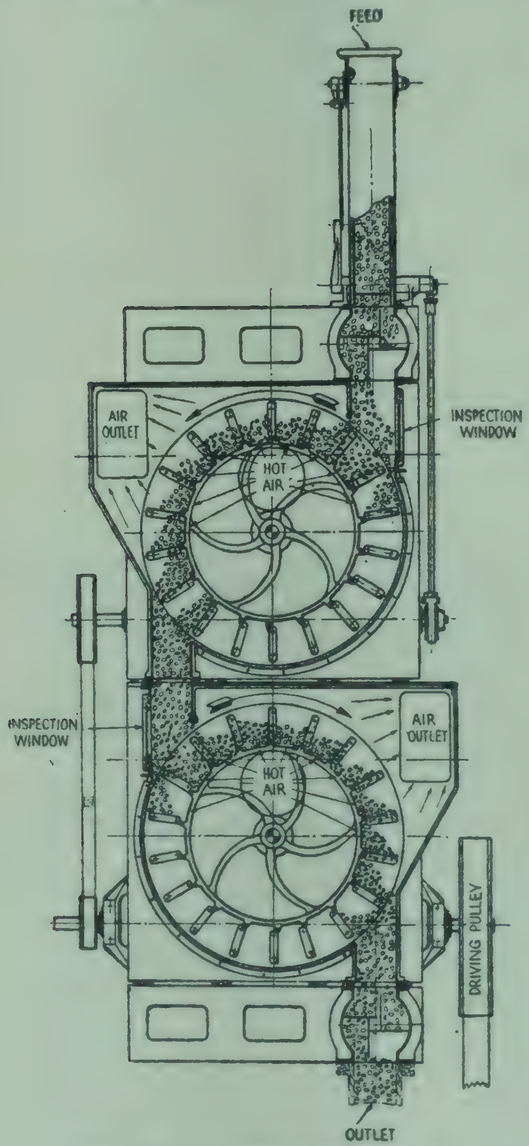


Fig. 165.—Turner cascade dryer.

The dried flakes then pass through a cooling section, which is the same as the drying section except that hot air is replaced by cold, and are finally discharged through another air lock. A fan and air heater supply hot air, the dryer being belt driven. This machine has a gentle action and prevents the breaking of the flakes.

(b) *The Thermo-Pneumatic System*

Another method of drying and cooling maize flakes is by a Thermo-Pneumatic plant made by W. S. Barron & Son Ltd. In this method the flakes are conveyed pneumatically and are dried and cooled by the same air which is used to convey them. The flakes are spouted from the flaking roll into a self cleaning rotary seal which delivers them to the drying trunk. Hot air is drawn by a fan from a heater and is blown together with the flakes into a specially designed drying cyclone from which the moisture laden air escapes at the top.

The dried flakes are then spouted to a second rotary seal and so into the cooling trunk, along which they are blown by a cold air fan into a cooling cyclone discharging into the sack. Heavier flakes laden with moisture are blown along more slowly than lighter, drier flakes and the wetter flakes are, therefore, exposed to the hot air for a longer period. This reduces variation in the moisture content of the finished product but on the other hand, there is more danger of breaking the flakes, compared with the cascade dryer.

(*c*) *Robinson Band Dryer*

A third method of drying and cooling maize flakes is by a band dryer, as made by Thos. Robinson & Son. The machine consists of an endless conveyor of perforated plates mounted on a chain and sprockets, the whole being encased in a sheet metal box; it is divided into two compartments, one above the other, hot air being drawn through the upper compartment and cold air through the lower.

The flakes from the rolls are evenly spread across the conveyor and conveyed slowly along it. As each plate reaches the end sprocket, it tips and deposits the flakes on the under side of the conveyor where they are returned to the feed end. The dried flakes are then discharged into the lower, cooling department where they are again conveyed to and fro in the same way.

The conveyors are driven through worm gears encased in oil baths, and scrapers, which collect and discharge any dust through the outlets, are provided in the bottom of the boxes.

Chapter XVIII

THE MANUFACTURE OF MIXED POULTRY CORN, CUT, KIBBLED AND ROLLED GRAIN

1. MACHINES

A. CORN CUTTERS AND GRADERS

A Corn Cutter, for cutting maize or wheat may be supplied either as a separate machine (Fig. 166) or complete with grader for grading the various sizes of cut corn (Fig. 167). Alternatively, a separate oscillating sieve may be used as a grader.

(1) *The Barron Cutter*

The Barron machine (Fig. 166) consists of a cast iron casing (1) with the upper half hinged at (2) to give access to the internal mechanism. The cutting is done by four knives (3), which are mounted on a cast iron spider carried on a shaft (4) running in ball bearings. The revolving knives cut the grain against two stationary knives (5), the clearance between the revolving and stationary knives being set by a gauge supplied with the machine. This clearance can be adjusted as required.

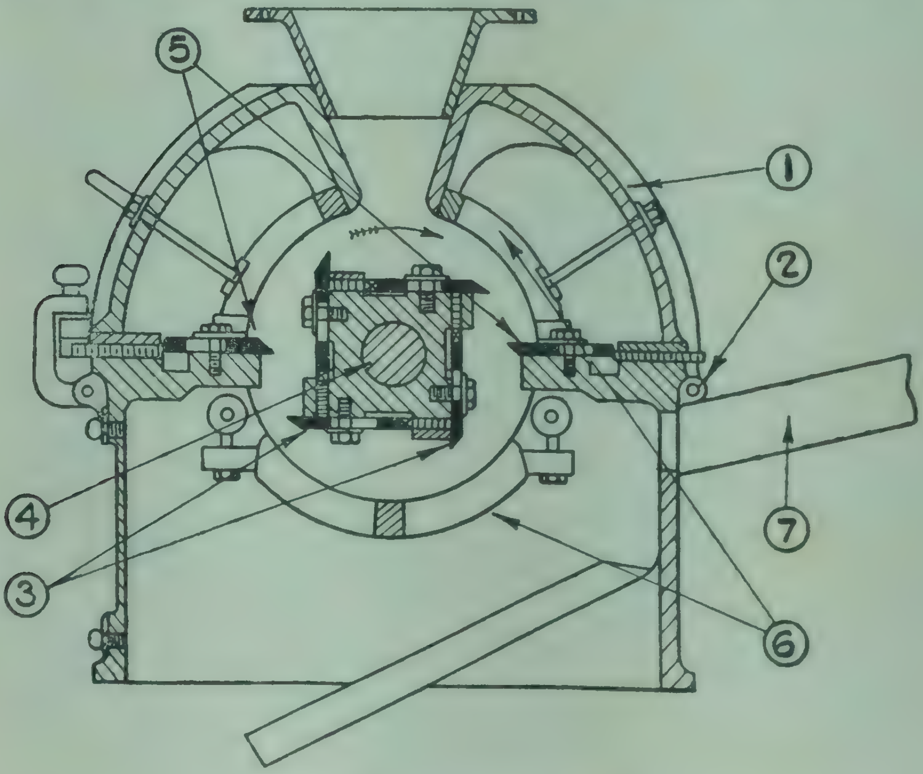


FIG. 166.—Barron corn cutter.

1. Cast iron chamber. 2. Hinges. 3. Four revolving knives. 4. Knife shaft. 5. Two stationary knives. 6. Perforated removable screen. 7. Exhaust trunk.

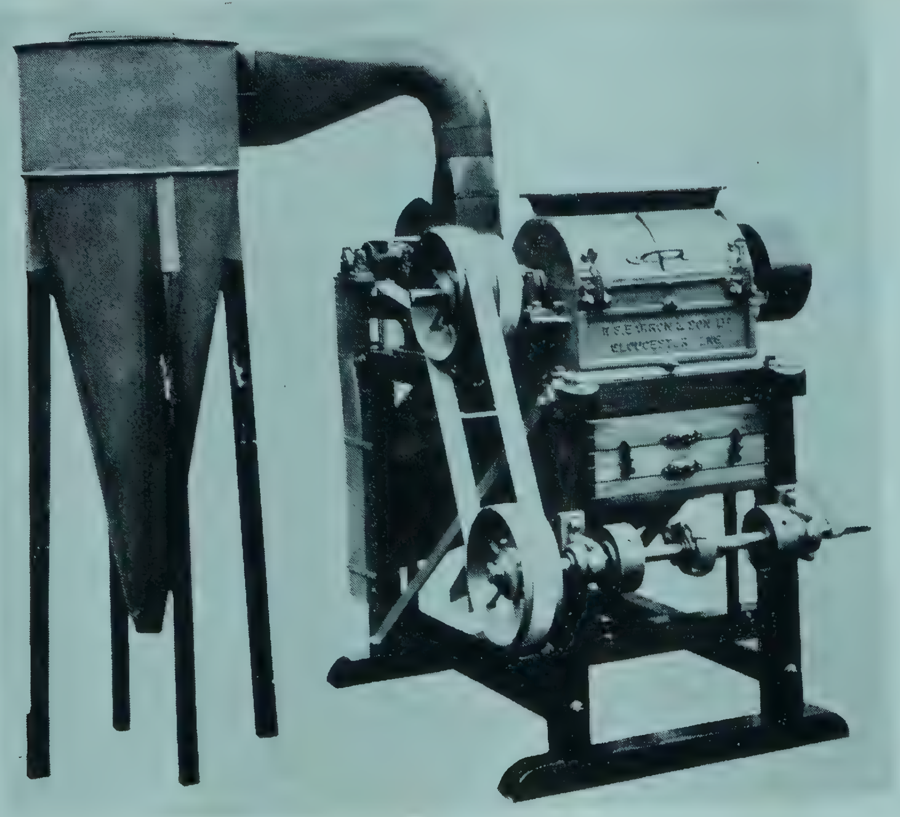


FIG. 167.—Barron corn cutter and grader.

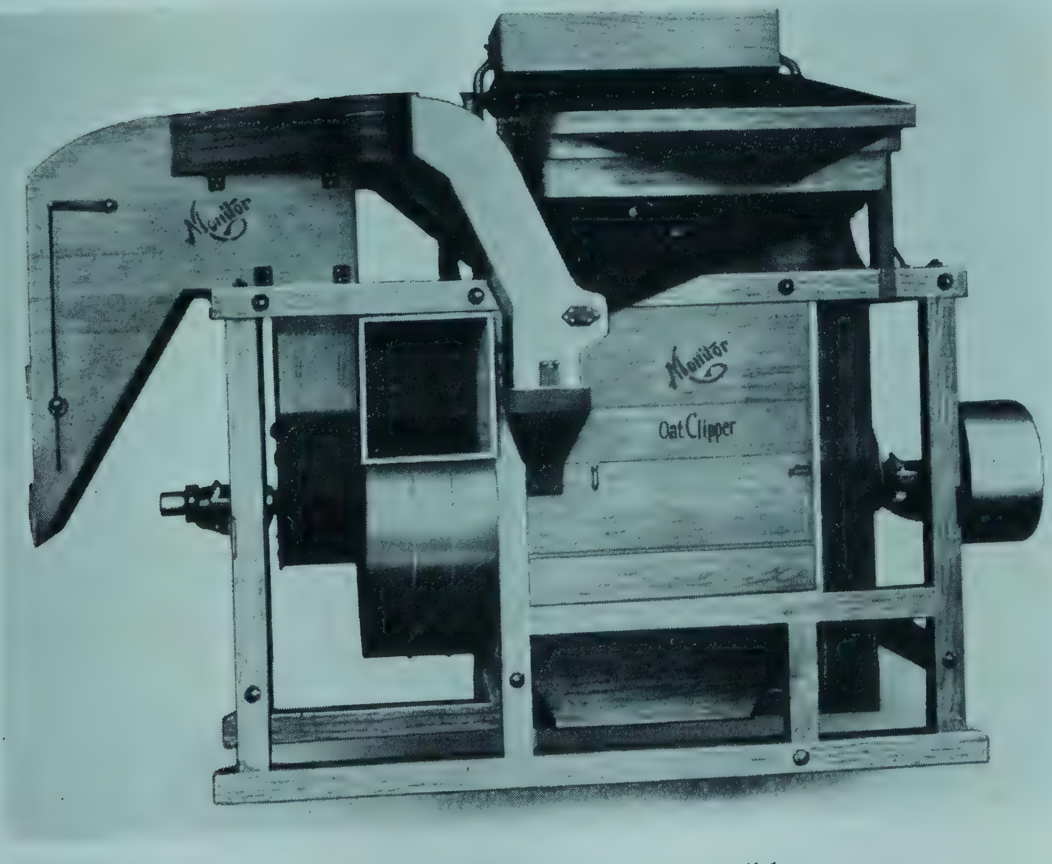

Monitor
Monitor
Oat Clipper

FIG. 168.—Porteus oat clipper and polisher.

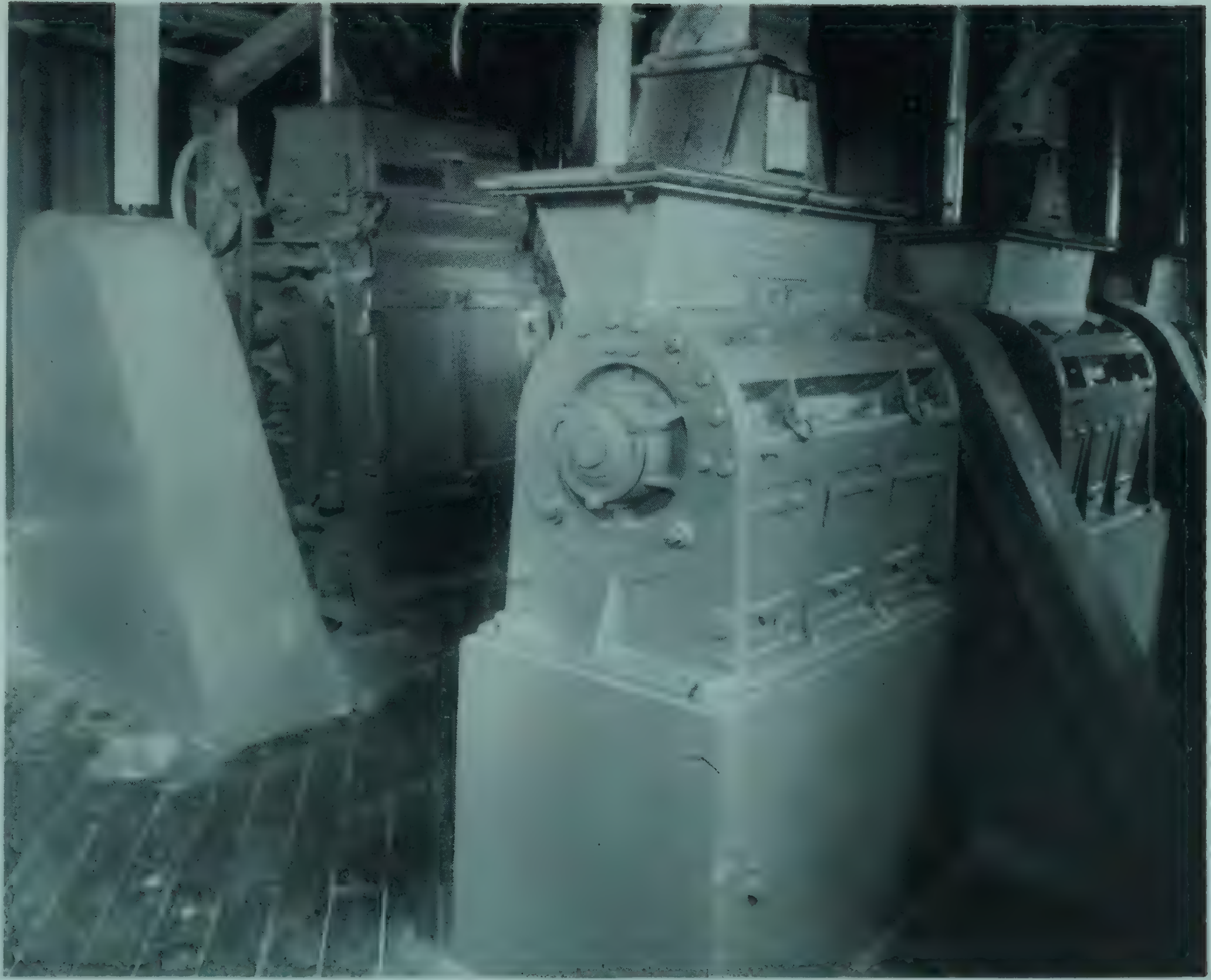


FIG. 169.—A line of corn cutters.

The knives revolve at 570 to 700 r.p.m. according to the size of machine; they are encircled by removable perforated screens (6), carried in cast iron frames, which determine the size of the product leaving the machine.

The above description applies to the small capacity No. 1 machine. The larger sizes, the No. 2 and No. 3 machines, have six revolving and two stationary knives.

(2) *The Barron Corn Cutter and Grader*

Fig. 167 shows the corn cutter and grader outfit, the corn cutter being mounted on the wooden frame of the grader. The grader consists of three inclined sieves enclosed in a frame and oscillated by an eccentric drive. The product leaving the cutter falls on to the sieves and is graded into coarse, medium and fine grits, the throughs of the bottom sieve being meal.

A self-contained fan, which is driven from the cutter shaft, is mounted on the machine and aspirates each grade of stock independently as it tails over each sieve; the cutter itself is not aspirated in later models, the aspiration being confined to the materials leaving the cutter. The fan discharges into a small self-contained cyclone.

Fig. 169 shows a line of corn cutters in a modern mill.

(3) *The Howes Corn Cutter and Grader*

This machine, which is manufactured by S. Howes & Co., is similar in general arrangement to the Barron machine. It consists of four revolving knives and two fixed knives in a cylindrical chamber fitted with a perforated screen and has three sieves oscillated by eccentrics, with self-contained fan and cyclone.

B. Oat Clippers and Polishers

(1) *The Porteus Combined Oat Clipper and Polisher*

This machine, made by George Porteus & Sons (Leeds) Ltd. (Fig. 168), may be used for either oat clipping or polishing as required. The grain passes first to a reciprocating sieve fitted with two interchangeable screens, one to extract foreign matter or large grain and the other sand or thin grain. A valve is fitted to enable the sieved grain to pass either into the clipping or polishing cylinder or direct to the aspiration chamber.

The perforated metal cylinder is stationary; it contains a rotating shaft which carries either beaters for clipping or brushes for polishing; the beaters and brushes are readily interchangeable and adjustable. The husks and dust pass through the cylinder into a collecting hopper, the clipped or polished grain overtailing into the aspirating section. The feed to the aspirating section is evenly spread by a counter-weighted valve and the liftings are collected in an expansion chamber. A valve controls the amount of aspiration. The main beater or brush shaft also carries the fan which is contained in the aspirating section. This shaft and the eccentric drive to the oscillating sieve are both fitted with ball bearings.

(2) *The Monitor Combined Oat Clipper and Polisher*

This machine is made by S. Howes & Co., and is similar in general principle to the Porteus machine.

(3) *The Barron Oat Clipper*

This machine is also similar in general principle to the Porteus machine, but smaller in design.

C. Oat Crushing Rolls

(1) *Standard Roller Mills*

Standard roller mills, as referred to in Chapter IX, may be used for oat rolling or crushing, but Messrs. W. S. Barron & Son manufacture a special machine for this purpose. It is designed for the provender miller, and has a capacity of 10-20 cwt. of rolled oats per hour.

(2) *The Barron Oat Roller Mill*

The Barron Oat Roller Mill (Fig. 170) consists of a feed roll and an adjustable slide which delivers the oats in a thin stream between two chilled iron horizontal rolls which are supported on a cast iron frame. The back roll is fixed, the front adjustable, and both run at 250 r.p.m. by friction without the use of gearing.

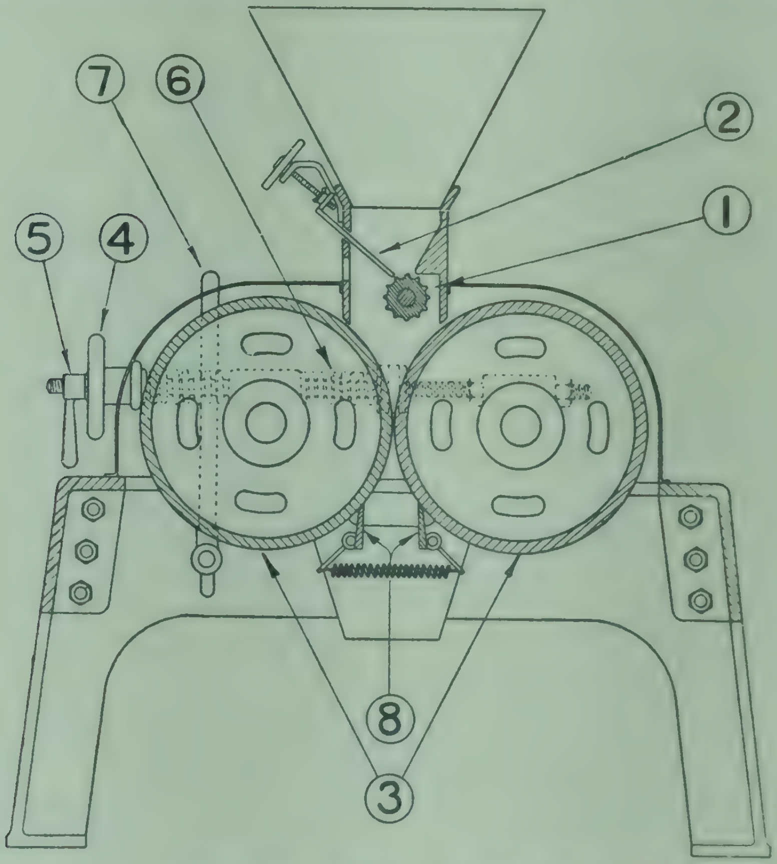
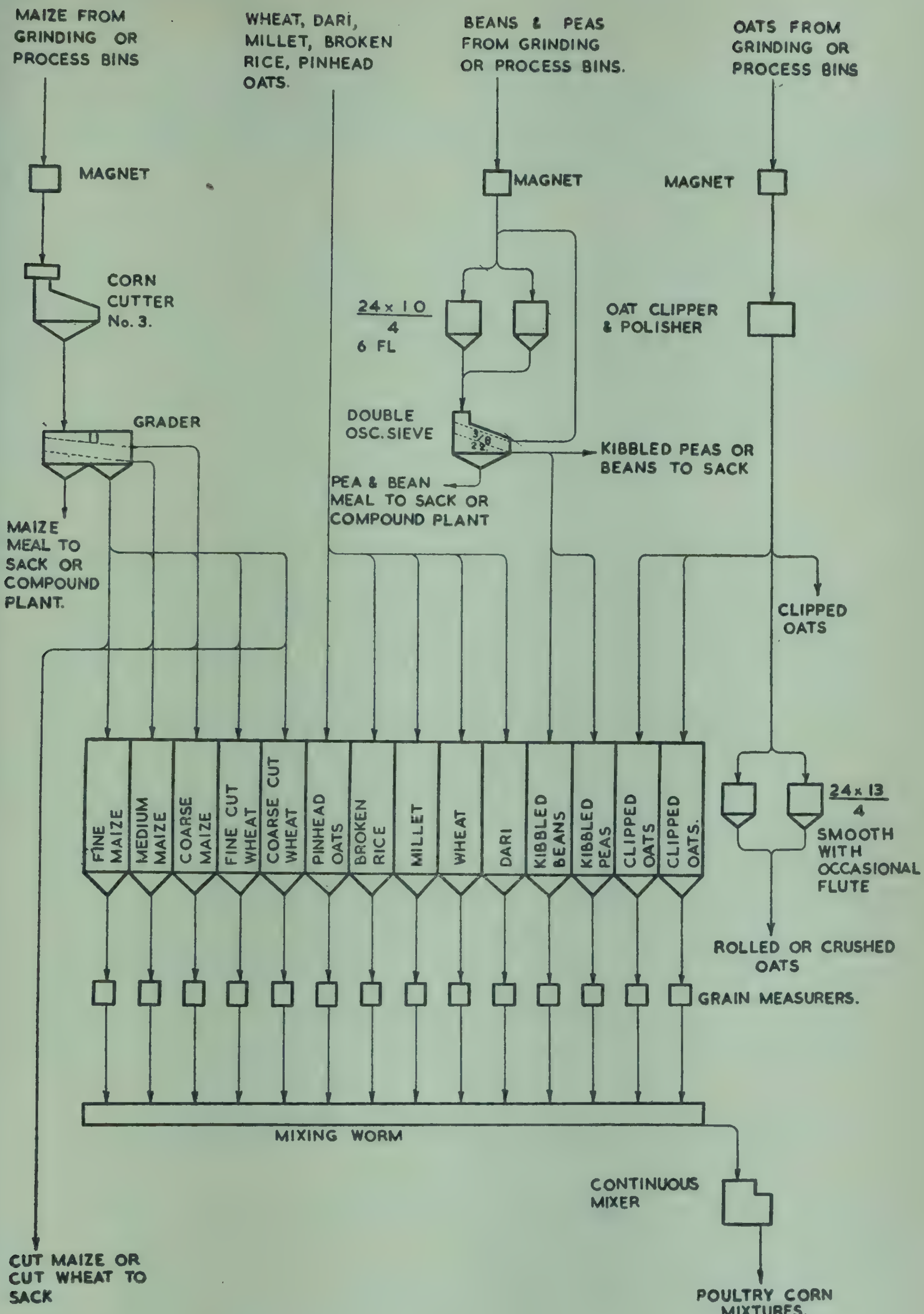


Fig. 170.—Barron oat rollermill.

1. Feed roll. 2. Adjustable slide. 3. Two chilled iron rolls. 4. Roll adjustment handwheels. 5. Locking nut. 6. Pressure springs. 7. Throw-out lever. 8. Scrapers.

The pressure between the rolls is adjusted by handwheels fitted with lock nuts at each end of the roll and is transmitted through strong coil


MAIZE FROM GRINDING OR PROCESS BINS
WHEAT, DARI, MILLET, BROKEN RICE, PINHEAD OATS.
BEANS & PEAS FROM GRINDING OR PROCESS BINS.
OATS FROM GRINDING OR PROCESS BINS
MAGNET
MAGNET
MAGNET
CORN CUTTER No. 3.
24 x 10 / 4 / 6 FL
OAT CLIPPER & POLISHER
GRADER
DOUBLE OSC. SIEVE
KIBBLED PEAS OR BEANS TO SACK
PEA & BEAN MEAL TO SACK OR COMPOUND PLANT
MAIZE MEAL TO SACK OR COMPOUND PLANT.
CLIPPED OATS
FINE MAIZE
MEDIUM MAIZE
COARSE MAIZE
FINE CUT WHEAT
COARSE CUT WHEAT
PINHEAD OATS
BROKEN RICE
MILLET
WHEAT
DARI
KIBBLED BEANS
KIBBLED PEAS
CLIPPED OATS
CLIPPED OATS.
24 x 13 / 4
SMOOTH WITH OCCASIONAL FLUTE
ROLLED OR CRUSHED OATS
GRAIN MEASURERS.
MIXING WORM
CONTINUOUS MIXER
CUT MAIZE OR CUT WHEAT TO SACK
POULTRY CORN MIXTURES.

THE MANUFACTURE OF MIXED POULTRY CORN.

Fig. 171.

springs which allow the rolls to move apart if any obstruction enters them. A throw-out lever enables the rolls to be opened and closed without disturbing their adjustment. Roll scrapers fitted with springs are also provided.

2. PROCESSES

Fig. 171 shows a flow diagram of a plant for the manufacture of mixed poultry corn, which includes the manufacture of cut maize or wheat, kibbled beans or peas, clipped and rolled oats. A preliminary cleaning, and with some materials a preliminary damping of the grain, is necessary in conjunction with all these operations, and is carried out on a warehouse separator and damping wheel respectively before the process bins. These process bins may be arranged in the same group as the grinding bins for the compound plant.

A. The Manufacture of Cut Maize or Cut Wheat

Roller mills or sometimes disc grinders may be used for cut maize, but for poultry corn mixtures, maize and wheat are usually cut on corn cutters (Fig. 166) because the knives give a clean cut and the resultant grits are cleaner and brighter. Roller mills, on the other hand, although producing an inferior kibbled product, have a greater capacity and lower maintenance costs. Knives of corn cutters have to be sharpened after every 100 tons production, but disc grinders will handle approximately 4000 tons without renovation, and fluted rolls will last even longer.

The grader attached to the corn cutter illustrated in Fig. 167 separates the cut products into coarse, medium or fine grits, which may either be sacked off individually for direct sale, or sent to the bins in readiness for mixing into the poultry corn. The grits are aspirated by a fan and cyclone attached to the grader which, with the help of the clean cut action of the knives, gives the grits a bright and clean appearance. When cutting maize, the perforated screen surrounding the cutter knives is usually $\frac{9}{32}$ in. round hole mesh and the clearance between the revolving and fixed knives $\frac{3}{32}$ in. When cutting wheat the cutter screen should be $\frac{5}{32}$ in. and the clearance $\frac{1}{32}$ in.

The grader screens are normally clothed with the following perforations :

Top screen	No. 11 round hole (4·36 mm.)
Bottom screen (top half) . .	No. 9½ round hole (2·85 mm.)
Bottom screen (bottom half) .	No. 7 round hole (1·75 mm.)

With these meshes the percentages of maize grits are approximately as follows :

	per cent
Coarse grits over No. 11 screen	70
Medium grits over No. 7 screen	20
Fine grit through No. 9½ screen	5
Meal through No. 7 screen	5

If desired, a larger percentage of medium grits can be obtained by fitting a slightly finer screen in the cutter.

The capacity of the Barron range of machines on all grades of grits or cut grain is as follows:

Maize

Machine No.	*per hour*
1	14 cwt.
2	1 ton
3	2 tons

Wheat

Machine No.	*per hour*
1	5 cwt.
2	9 cwt.
3	15 cwt.

Variation will occur, of course, according to the quality of grain. If the knives become blunt, the proportion of meal is increased and the screens tend to become blocked.

B. The Manufacture of Kibbled Beans and Peas

Kibbled or split beans and peas are most satisfactorily made on a fluted roller mill. This has five flutes to the inch on the top roll and seven on the bottom. The kibbled grain is graded on an ordinary oscillating sieve, the overtails of the top screen returning to the roll, the overtails of the bottom screen being kibbled beans or peas, and the throughs of the bottom screen being the meal which may be sacked off or delivered to the compound plant. The top screen normally consists of a $\frac{3}{8}$ in. perforated round hole mesh and the bottom a 22 fine wire. As in the case of cut maize and wheat, the kibbled product is of brighter, cleaner appearance if subjected to aspiration. The capacity of the plant (Fig. 171) is approximately 1 ton per hour.

C. The Manufacture of Clipped and Rolled Oats

In Fig. 171 an oat clipper is shown before the oat roller mill, although oat clipping is not essential for the production of rolled, or crushed oats. If, however, the hairy extremities of the oat are removed, a much better quality product of improved bushel weight is made. Also, when oats are fed to horses, clipping is to be recommended because the hairy, fibrous ends are liable to cause throat irritation.

Crushed oat rolls should be fluted with one flute to every 5 inches to enable the oats to grip the rolls, and a slight differential, even as little as one tooth difference in the gears, is also beneficial.

THE MANUFACTURE OF MIXED POULTRY CORN

The preparation of mixed poultry corn consists of mixing together all the individually processed grains just described. As shown in Fig. 171, the processed grains are sent direct from each plant to a central range of poultry corn bins together with other grains not requiring processing, such as whole wheat, dari millet, broken rice and pinhead oats. Each type of grain is then blended by a grain measurer under each bin and mixed on the continuous principle by a worm conveyor. A continuous mixer may be employed as shown in the diagram, but normally the worm conveyor should give a sufficient mixing provided it is at least 10 ft. long after the entry of the grain from the end bin.

Volumetric blending is normally suitable for this type of plant. However, if particular accuracy is required, the synchronised weigher system may be used, which incorporates a range of standard size weigh buckets with electrically controlled tipping as described on page 167. This is much more expensive than the volumetric method.

The plant shown in the diagram (Fig. 171) is suitable for a capacity of 10 tons per hour upwards. In smaller plants, vertical batch mixers may be used satisfactorily but, as these take much labour, the most economical type of small capacity plant should be designed on the same continuous basis as shown in Fig. 171, but with simplifications.

A series of small hoppers may be arranged in one frame and the more elaborate grain measurers may be replaced by slides controlled by simple rack and pinion devices. Small oscillating sieves, also acting as feeders, may be arranged between the slides and the mixing worm to extract dust.

It is important that mixed poultry corn should be clean, free from dust and of bright appearance. Although dust is separated in the individual processing plants, some is liable to recur with the subsequent handling of the grain in the bins and in the mixing process. Therefore, although it is not shown in the diagram, it is strongly recommended that the grain should again be subjected to sieving or aspiration and, preferably, this should be the last operation before packing.

Chapter XIX

EXHAUST SYSTEMS IN COMPOUND MILLS

1. INTRODUCTION

EXHAUST systems used in compound mills are not at present usually as comprehensive or as carefully thought out as those in flour mills. In a flour mill, the exhaust system is an important factor in the manufacturing process and, therefore, receives due consideration by the miller, but in the compound mill, the inclusion of an efficient exhaust system has received little attention in the past.

Owing to the large number of different kinds of raw materials and the various types of plant involved, many of the exhaust problems are more difficult than those experienced in flour mills, where the raw material is limited to one kind of grain and one type of plant. There is no reason, however, why a compound mill should not be provided with an efficient exhaust system, and modern millers are now earnestly tackling this subject on the lines indicated in this chapter.

2. REASONS FOR EXHAUST SYSTEMS

The reasons for an efficient exhaust system may be summarised as follows :

(1) By drawing off warm, moist air to prevent condensation, excessive evaporation loss, and mouldiness in the product and to ensure the cool and efficient running of machines at full capacity.
(2) To prevent dust from escaping to the atmosphere, thereby eliminating waste and public nuisance in town areas.
(3) To prevent dust concentrations in the mill which increase the risk of explosions and fires.
(4) To improve working conditions for the operators and the appearance of the mill.

TYPES OF EXHAUST SYSTEMS IN COMPOUND AND AUXILIARY PLANTS

Exhaust systems may be grouped into six categories :

(1) Self-contained pneumatic delivery systems for high speed percussion grinders.
(2) Independent exhaust on individual machines and plants.
(3) Central exhaust systems covering a number of machines and plants.
(4) The exhaust of steam to atmosphere.
(5) Closed circuit systems within a machine.
(6) The separation of dust and light particles by density and air currents.

(1) PNEUMATIC DELIVERY SYSTEMS

In the pneumatic delivery system, exemplified in Fig. 172, a built-in fan draws the ground material from under the grinder and blows it, together with the air, through trunking under pressure into a self-contained cyclone dust collector. The air passes out of the cyclone top or thimble and the separated product delivers through the bottom outlet. This system has the advantage that it exhausts the hot air from the grinder at the same time as it elevates the material to a higher floor, no other exhaust or elevator being necessary. The air is also drawn through the grinder screen, thus assisting to keep it clean and maintain its capacity.

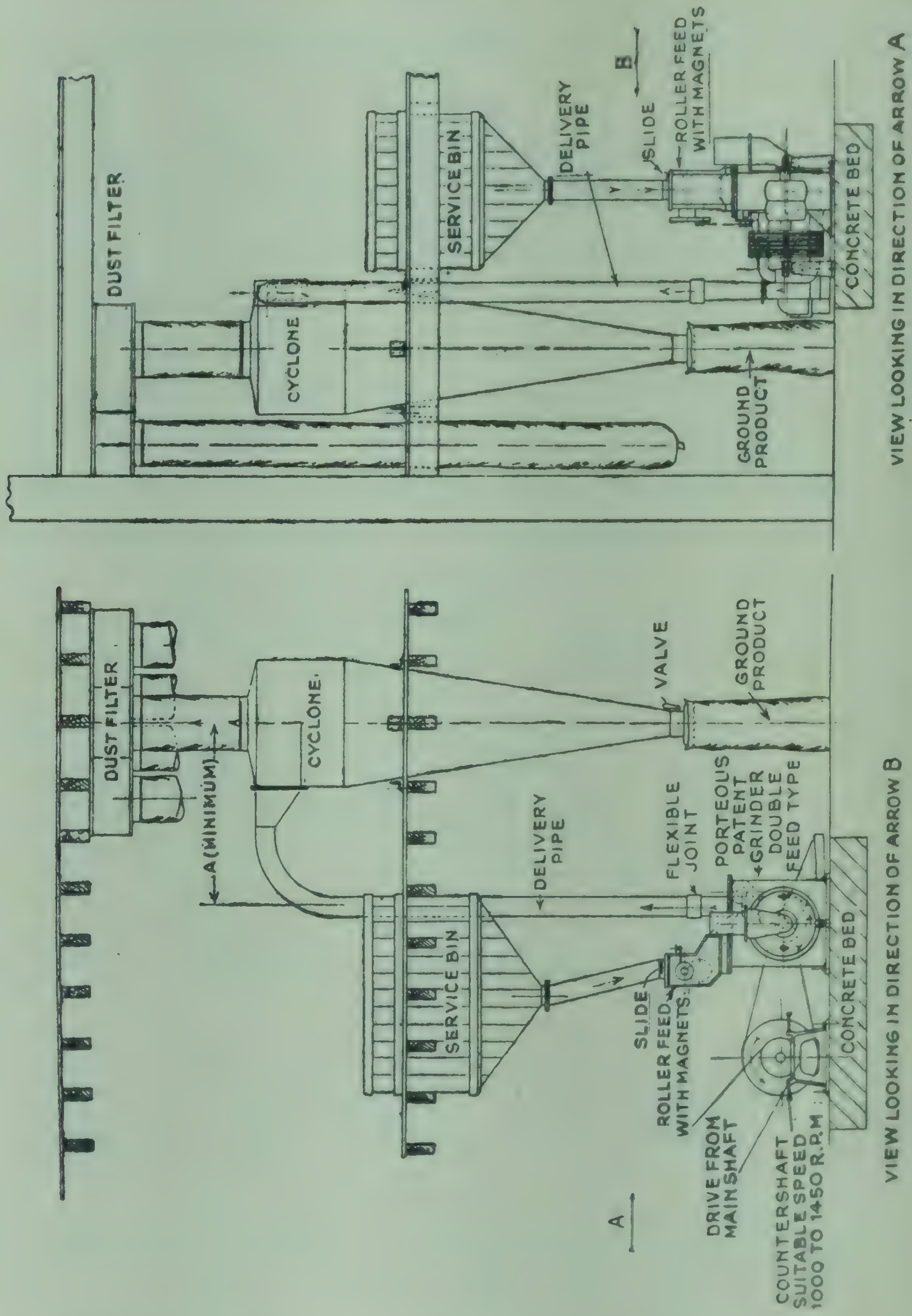

DUST FILTER
CYCLONE
SERVICE BIN
DELIVERY PIPE
SLIDE
B
ROLLER FEED WITH MAGNETS
GROUND PRODUCT
CONCRETE BED
VIEW LOOKING IN DIRECTION OF ARROW A
DUST FILTER
A (MINIMUM)
CYCLONE
VALVE
GROUND PRODUCT
DELIVERY PIPE
FLEXIBLE JOINT
PORTEOUS PATENT GRINDER DOUBLE FEED TYPE
SERVICE BIN
SLIDE
ROLLER FEED WITH MAGNETS
DRIVE FROM MAINSHAFT
COUNTERSHAFT SUITABLE SPEED 1000 TO 1450 R.P.M.
CONCRETE BED
A
VIEW LOOKING IN DIRECTION OF ARROW B

FIG. 172.—Pneumatic delivery system for percussion grinders (blowing type).

Metal cyclone dust collectors are usually employed because they are cheap, free from mechanical complications and of convenient size for a self-contained grinding plant. Their efficiency, however, compared with other types of dust collectors, is not high. Consequently, when material containing a large quantity of fine dust, such as some kinds of barley grain, is being ground, an excessive amount of dust will escape with the air from the top of the cyclone.

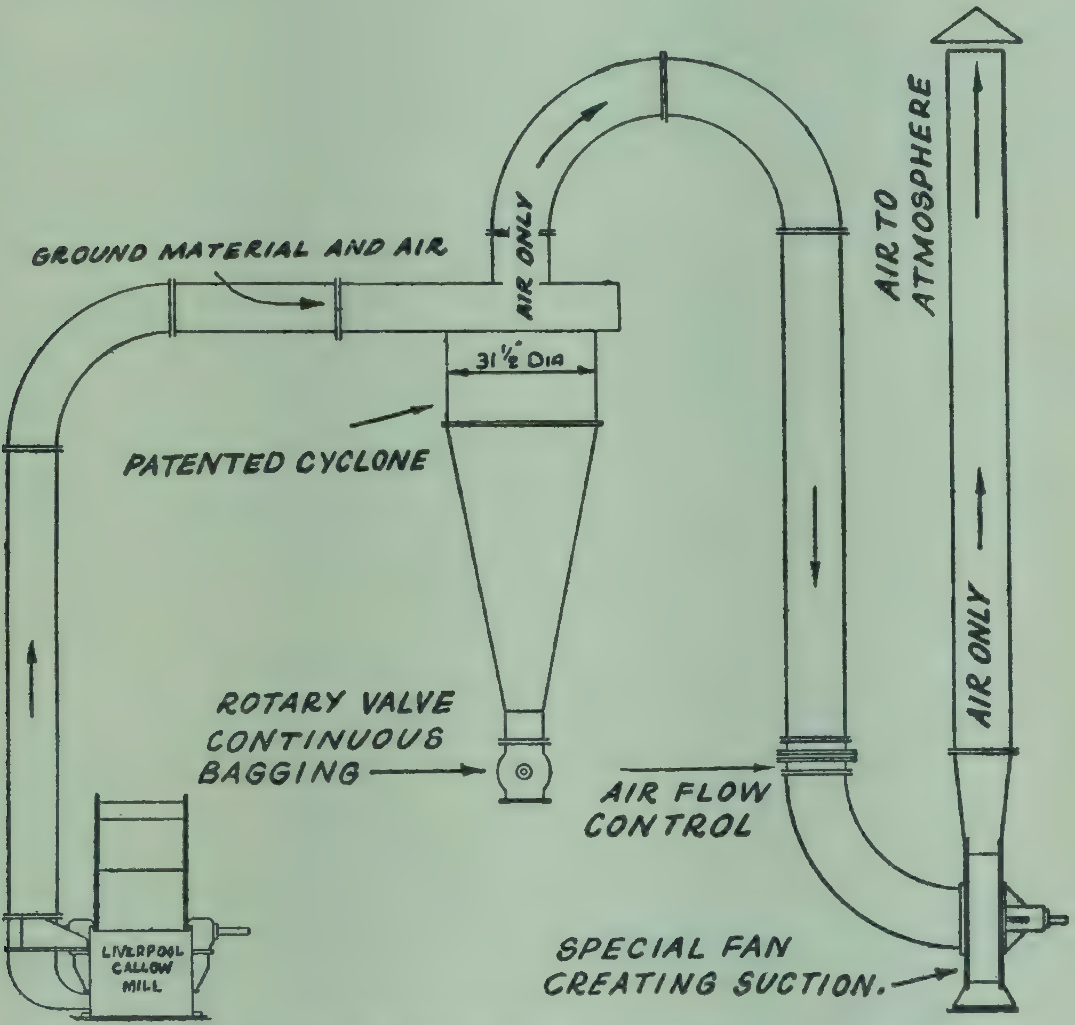

GROUND MATERIAL AND AIR
AIR ONLY
31½" DIA
PATENTED CYCLONE
AIR TO ATMOSPHERE
ROTARY VALVE CONTINUOUS BAGGING
AIR FLOW CONTROL
AIR ONLY
LIVERPOOL CALLOW MILL
SPECIAL FAN CREATING SUCTION.

FIG. 173.—Pneumatic delivery system for Callow grinder (suction type).

To prevent this, cyclones employed in pneumatic systems are sometimes provided with a horizontal metal trunk attached to the thimble of the cyclone, from which a series of textile sleeves, tied at the bottom, are hung to collect the dust.

A disadvantage of this method is that if the texture of the sleeves is too coarse, dust penetrates into the room. On the other hand, if they are too fine, they tend to clog and pressure is then set up inside the cyclone, resulting in dust laden air being blown out of the bottom with the product. In the Porteus Grinder, it is claimed that these difficulties are minimised if a certain amount of air is exhausted before it reaches the dust filter by inserting another filter sleeve of 2 ft. 6 in. diameter minimum, as shown in Fig. 172, between the thimble of the cyclone and trunk from which the other textile sleeves are hung.

These blowing systems are, however, being gradually superseded by the more modern type of suction pneumatic plant. A typical example (Fig. 173) is the plant made by F. E. Callow (Engineers) Ltd., in conjunction with their hammer mill. In this system the air and ground material is drawn from the grinder by an independent fan. The air is separated from the meal at the top of the cyclone and, after passing to the suction side of the fan, is blown direct to atmosphere.

Suction plants have many advantages over those of the blowing type; they are much cleaner and eliminate the necessity for exhaust boxes and filter sleeves; they increase the output of the grinder and, as the ground material does not pass through the fan, the wear of the fan blades is reduced.

Another type of suction plant works on the closed circuit principle in which the air, after being separated from the meal by the cyclone, is returned to the grinder. Fig. 174 shows the plant made by W. S. Barron & Son Ltd. In this plant the dust and moisture of the product being ground is retained in the circuit. This not only makes the plant much cleaner, but reduces the evaporation loss as caused by other grinding systems.

It should be noted, however, that any closed circuit principle sets up pressure and increased temperature inside the system. To overcome this, a small ‘ breather ’ cyclone, as shown in the illustration, is introduced in the return air trunk. This also provides for a second separation of dust-laden air.

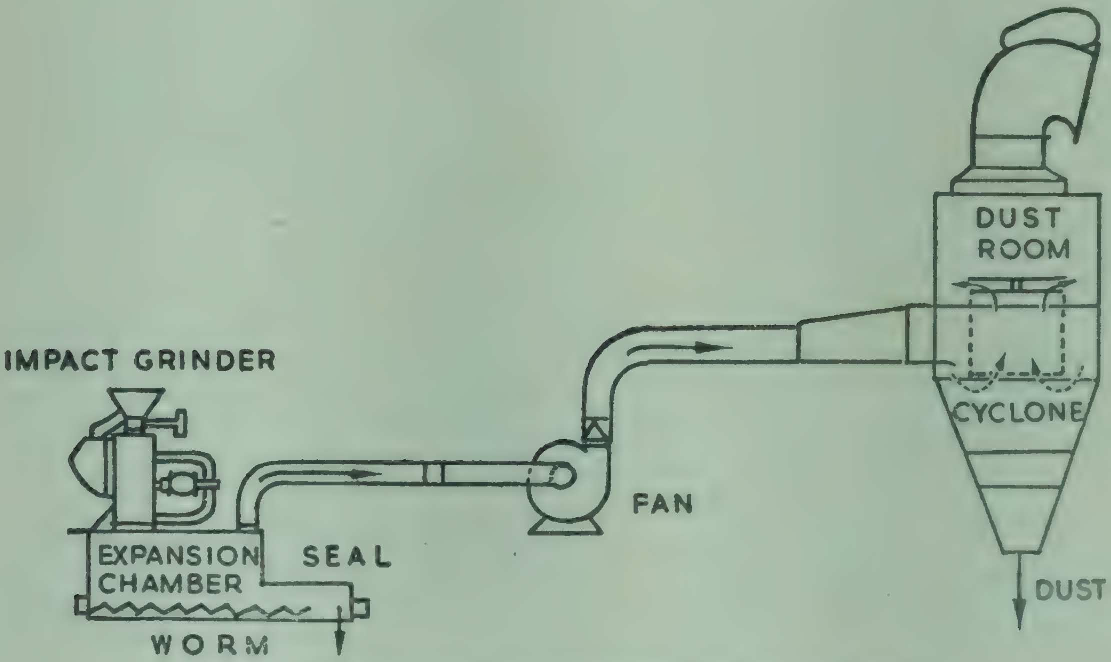


FIG. 175.—Independent exhaust system for separate plants.

(2) INDEPENDENT EXHAUST ON INDIVIDUAL MACHINES AND PLANTS

These exhaust systems draw away dust laden air from machines and plants by fans and deposit it into dust collectors as shown in Fig. 175. The fans, in some cases, may be contained in the machine itself, as, for example, in warehouse separators, and sometimes both the fan and cyclone dust

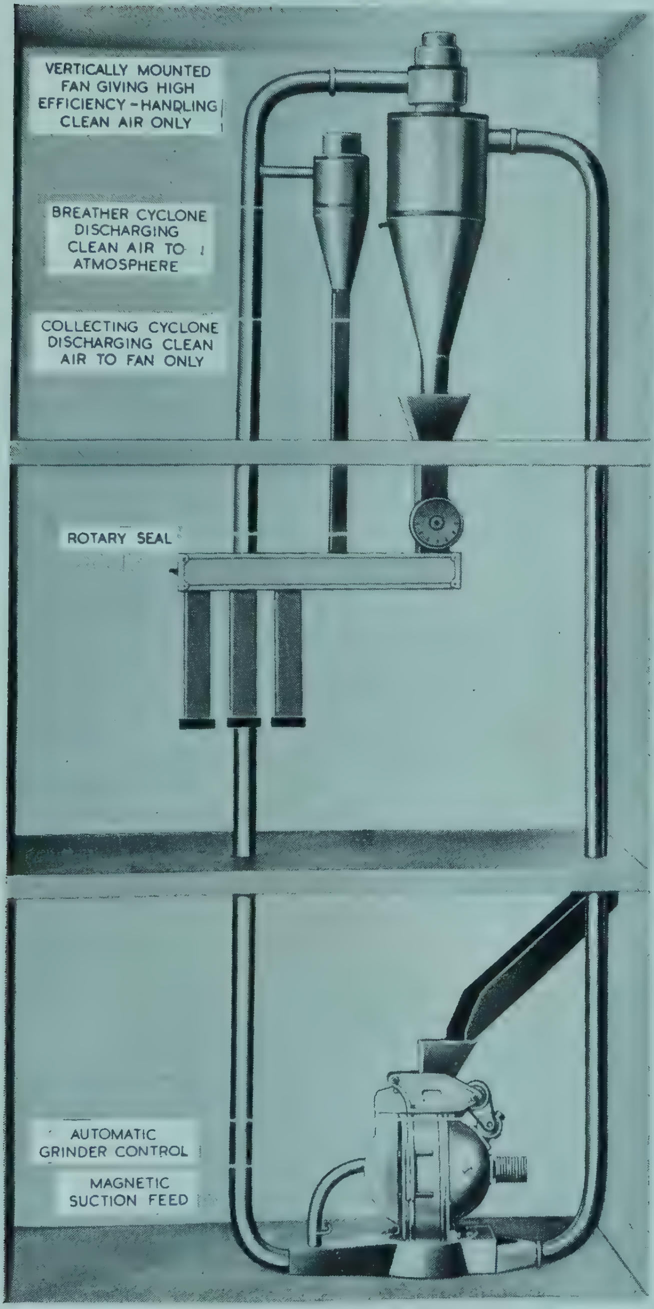

VERTICALLY MOUNTED FAN GIVING HIGH EFFICIENCY - HANDLING CLEAN AIR ONLY
BREATHER CYCLONE DISCHARGING CLEAN AIR TO ATMOSPHERE
COLLECTING CYCLONE DISCHARGING CLEAN AIR TO FAN ONLY
ROTARY SEAL
AUTOMATIC GRINDER CONTROL
MAGNETIC SUCTION FEED

FIG. 174.—Pneumatic delivery system for Barron impact (E type) grinder (suction type).

collector may form part of the machine as in corn cutters and graders. Cube and pellet coolers also have individual fans and cyclones. More often, however, one large fan and dust collector will exhaust all the various machines in a particular plant, as, for example, a rollermill plant, a stone or attrition grinder plant, or a high speed percussion grinder plant.

As an alternative to the pneumatic delivery system in grinder plants, metal expansion hoppers of ample capacity may be built under the grinder to allow the air to expand and the heavier dust to settle in the hopper. A worm conveyor in the hopper bottom, which has a rotary air seal at its delivery end, delivers the ground product to a bucket elevator. If the worm conveyor is longer than the hopper, an efficient air seal may be formed by taking off the last few worm blades and so causing the material to back up in the conveyor.

It is important that the grinder hopper should be sufficiently large to minimise the pressure set up inside it. Excessive pressure will cause heat, resulting in the blinding of grinder screens and reduced production.

There is always a serious risk of explosion in the hopper, and explosion vents or trunks of ample cross sectional area must be fitted from the hopper to the outside of the building to relieve the pressure and to safeguard plant and personnel. These vents must conform with fire and Home Office Regulations. In addition, the hopper must be exhausted by a trunk to a fan and dust collector. The exhaust system from all high speed grinders should be self contained and separate from other exhaust systems, and the dust collector and all trunking must be of metal construction to conform to regulations.

Other machines such as rollermills, centrifugals, etc., are provided with fresh air inlets and are fitted with air ports for connecting to exhaust trunking.

(3) CENTRAL EXHAUST SYSTEM

The most modern exhaust system makes use of high air velocity which ensures that trunks are self cleaning. In this case, one central dust collector and fan with metal trunking and connections exhausts all the machines or plants. In this way, a number of small fans and dust collectors are eliminated and, if the system is carefully designed, frictional losses in the trunking are minimised and power is saved. Trunks should follow the shortest route possible to the fan inlet and bends should be kept to a minimum.

Suction filter dust collectors are the cleanest and most efficient to use with central exhaust systems. The whole of the trunking is then kept under suction, thereby preventing any leaking of dust which always occurs when a number of cyclone dust collectors are working under pressure. Also, if all the dust in the mill is collected and disposed of at one central point, labour is saved. Many types of compound milling machines may be centrally exhausted, including accessory equipment such as elevators, bins, hoppers, etc. Fig. 176 shows a typical central exhaust system incorporating a suction filter dust collector.

If connected to the central exhaust system, all exhaust pipes passing through the ceiling or walls of the fireproof grinder house must be fitted with fire valves and fusible links to satisfy the insurance company. This applies only to grinders fitted with expansion hoppers and not to the pneumatic delivery type because the latter are self contained in the separate grinder house.

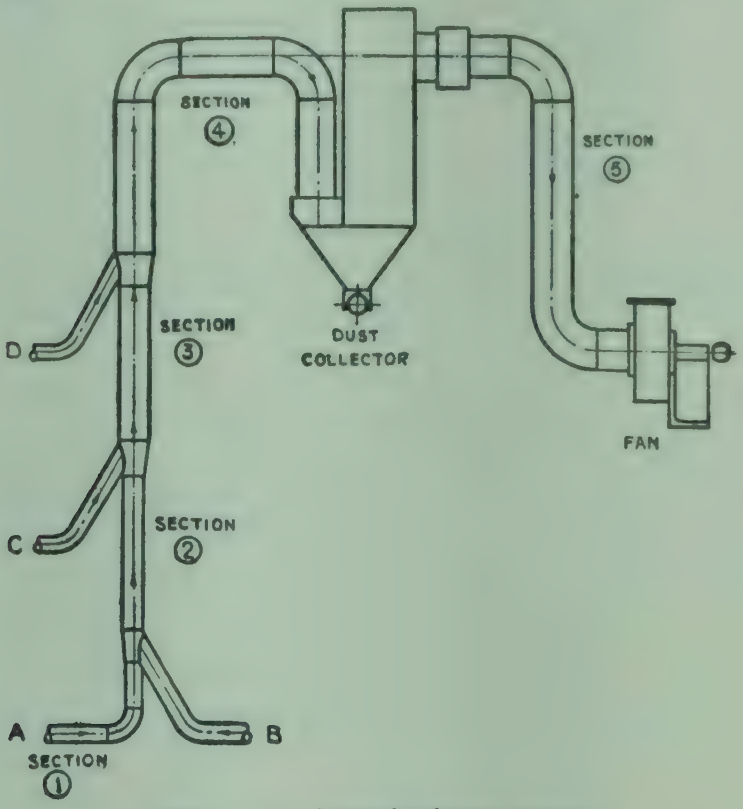


FIG. 176.—Central exhaust system.

There are, however, some machines and plants in compound mills which are not included in the above because they are more suitably exhausted by independent systems. High speed percussion grinder plants, for example, are housed in separate fireproof buildings to take full advantage of insurance rates. Also, machines handling hot, moist products, such as cube coolers, have separate cyclone exhausts because, if centrally exhausted filter dust collectors are used, moisture is liable to clog the sleeves.

The old method of trunking used in exhaust systems was to have mechanically cleaned square or rectangular wooden trunks usually of large cross sectional area, to which were connected the branch trunks from the various machines. The low velocity of the air allowed the dust to settle in the trunks and the cleaning mechanism consisted of an endless chain to which scraper bars were attached, the chain running over terminal sprockets and being driven from a shaft. These large trunks not only took up space but were a source of infestation.

The modern method is to have metal trunks of circular cross section in which the air velocity is such that the collectings are conveyed by the air current ensuring that the trunks are kept clean and free from dust. The design of modern high speed trunking is a complicated subject and one of the many which can be handled only by experts, but, briefly stated, the principle is to increase the cross sectional area of the main trunk as each branch trunk joins it. For example, if a branch pipe entering the main trunk is 4 in. in diameter, the main trunk will be increased by the area of a 4 in. diameter pipe at the point where the branch meets it. The branch pipe should enter the main trunk on the swell and the cross sectional area of the main trunk will then be the area of the first branch plus the area of the second. Branch pipes should be connected to the main trunk at not more than 30°. Sharp right angled bends should be avoided as they increase resistance and the consequent power requirements of the fan.

(4) The Exhaust of Steam to Atmosphere

In these cases, all that is required is a fan and trunk to draw away the surplus steam and hot air from the machines direct to the outside atmosphere, no dust collector being necessary. This system (Fig. 177) may be used to exhaust cereal cookers, flaking rolls and cubing machines, thereby reducing condensation and the dripping of water from surfaces inside the mill, and generally improving working conditions. Fans for this duty should be provided with a drain plug under the fan casing.

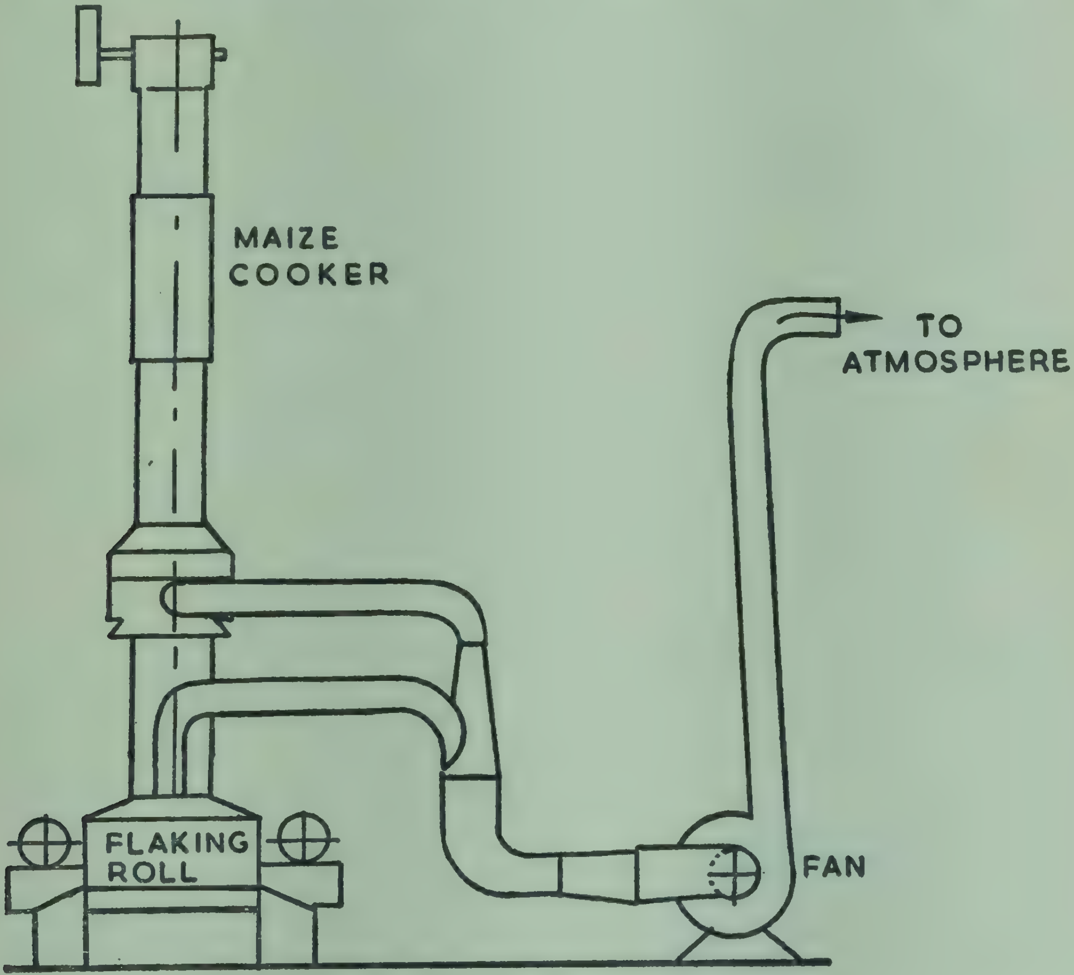


Fig. 177.—The exhaust of steam to atmosphere.

It is also beneficial to fit drains at suitable points in the trunking, to allow the condensation to drain away. The trunking should be heavily galvanised. In this way, the danger of corrosion is reduced.

5. Closed Circuit Systems

Closed air circuit systems with an internal fan and dust chamber may be incorporated in some types of self contained grain aspirating machines. In these systems, the same air is repeatedly cleaned and used inside the circuit and no external fan or dust collector is required.

A closed circuit aspiration, using only a simple expansion chamber, is more convenient and space saving, but is not so efficient as an ordinary open circuit machine because the air becomes charged with dust and the efficiency of the dust separation may be as low as 20 to 30 per cent.

6. Separation of Dust and Small Particles by Density and Air

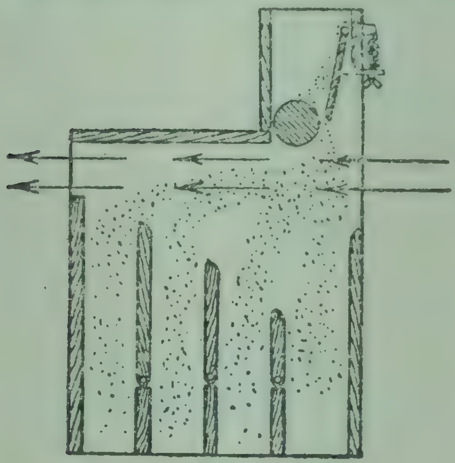


Fig. 178.—The separation of dust and small particles by density and air.

A common example of this system is the effective or gravity purifier as illustrated in Fig. 178.

The material is spread into a thin layer by a feed roll and feedgate, and a horizontal stream of air is then drawn through it. The heaviest particles fall straight into the nearest outlet and the lighter particles are blown into one of the remaining outlets. Hinged valves control the number of outlets and consequently the number of separations made. This is obviously a simple and inexpensive use of air currents, but it is useful only when an approximate separation of dust and light particles is required, and when a more expensive system is not justified.

FANS

The centrifugal type fan of steel construction is largely used in compound mills. In this type, which may be independent or built into the machine, the air is drawn into the eye of the rotor and is delivered at any point round the circumference. In the latest types, the fan casing is made so that it can be rotated to facilitate the erection of trunking at any angle, thereby eliminating undesirable bends.

Fan rotors of from six to eight blades or vanes are carefully balanced and run on ball bearings; they are made in various sizes and usually run at a speed of 250 r.p.m. to 2000 r.p.m., and have a capacity of between 600 and 20,000 cubic ft. of air per minute, depending upon their size.

To select the size of fan for a particular duty, it is necessary to determine the volume of air to be handled and the resistance of the ducting. The resistance is specified in inches of water and usually termed ‘ Static Pressure ’. The resistance is computed from the air velocity and diameter of ducting, due allowance being made for bends, junction points, etc.

With the introduction of Aerofoil fans for general exhaust purposes, a number of important advantages in efficiency, power consumption and flexibility have been achieved. The efficiency of axial flow fans is considerably higher than that of many of the centrifugal fans which have previously been available. In some cases, it is 30 to 40 per cent higher, their total efficiencies exceeding 70 per cent over a wide range of duties.

Aerofoil fans are made in single stage units comprising a cylindrical shell, housing a motor centrally disposed in the shell, the fan blades (impellers) being mounted directly on the motor spindle.

The fans are made in diameters varying from 6 in. to 48 in. giving a large range of capacities. Where high pressures are required, several stages can be built up to form a composite unit, each impeller revolving in the opposite direction to the adjacent stage. Due to this contra rotation of impellers, a two-stage unit will produce 2¾ times the pressure of a single stage fan without any appreciable increase in noise.

The use of a multi-stage unit enables a high degree of flexibility to be obtained. If it is desired to increase the capacity of a plant, it is a simple operation to install additional stages to increase the capacity of the fan unit.

A simple form of regulation is inherent in the multi-staged unit. By switching off and idling the first stage impeller of a two-stage fan, the air volume will be reduced by one-third and the power input by 60 per cent. Where four stages or more are employed, a much wider range of regulation can be obtained by running or idling the motors in various combinations. For example, it is quite practicable to reduce the volume of a four-stage fan to 50 per cent in five steps, or a six-stage fan to 20 per cent in a dozen steps. This system is more efficient than any form of regulation hitherto available, partly due to the low idling loss, but more especially to the fact that volume is reduced by switching motors off. The remaining motors, being fully loaded, continue to operate at maximum efficiency and power factor.

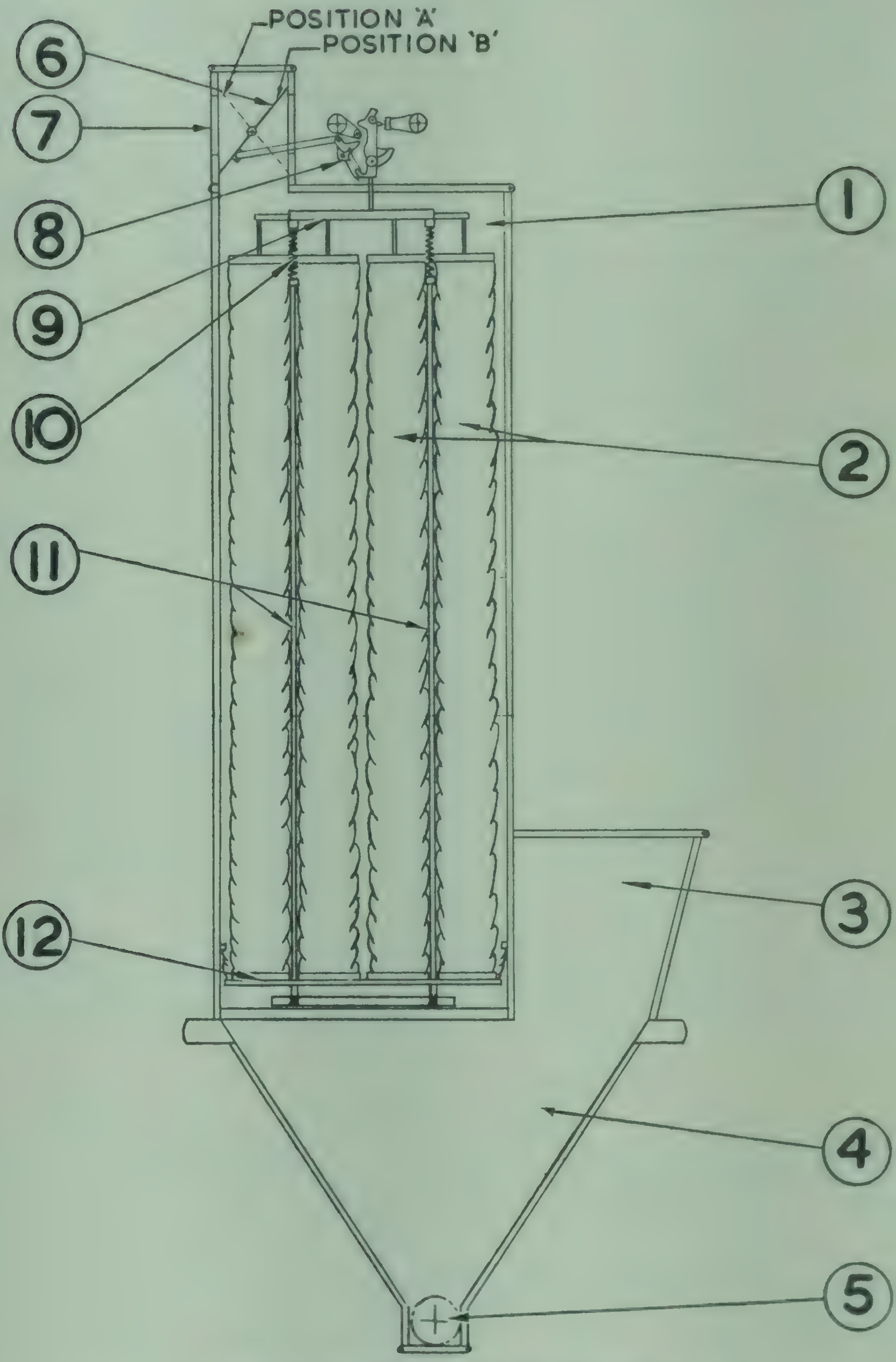
The driving motors of a multi-stage Aerofoil are identical and interchangeable. The independent drive for each impeller removes the risk of a complete fan shut-down, since a motor failure means only a reduction in air volume arising from the temporary loss of one stage.

An important point is that Aerofoil multi-stage fans can be inserted into runs of ducting without taking up space that can be usefully employed for other purposes. This is in marked contrast to the centrifugal fans used hitherto.

DUST COLLECTORS

The ordinary cyclone dust collector, which separates by centrifugal force, has an efficiency of from 70 to 90 per cent according to the type of dust handled. The remainder escapes with the exhaust air and may be collected either by a system of filter sleeves or a dust room. In spite of their low efficiency, however, cyclones are widely used in compound mills, because of their simplicity and cheapness. The efficiency of a cyclone increases as its size decreases.

Textile dust collectors consist of pressure and suction filter types. Pressure filters are not often used because they have the drawback that the air forces the dust into the mesh of the sleeves and, in spite of a cleaning grid, gradually chokes them. In a pressure filter, the dust laden air is forced under pressure into the dust collector, the air being blown through the sleeves into the atmosphere. In a suction filter, however, the cleaned air is sucked through the sleeves and blown to atmosphere.


POSITION 'A'
POSITION 'B'
⑥
⑦
⑧
⑨
⑩
⑪
⑫
①
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④
⑤

FIG. 179.—Suction filter dust collector.

1. Airtight compartments. 2. Textile sleeves. 3. Expansion box. 4. Hopper. 5. Worm. 6. Reverse air valve. 7. Outlet. 8. Shaking mechanism. 9. Supporting frame. 10. Springs. 11. Tie rods. 12. Supporting frame.

SUCTION FILTER DUST COLLECTOR

The machine (Fig. 179) is built up of a series of airtight compartments (1), varying from 2 to 12 depending on the capacity required, each compartment containing eight textile sleeves (2) each 8 in. diameter by 8 in. long arranged in two rows. The tops of the sleeves are closed, and the bottoms open into a common hopper (4) extending under each compartment.

The dusty air enters the hopper through an expansion box (3) and expands, depositing the heaviest particles in the hopper, from which they are propelled to an outlet by a worm (5). The air is then drawn up inside the sleeves and through them to the outlet (7) leaving the dust adhering to the inner surface of the sleeve. The outlets of each compartment are joined together by a common manifold and taken to a fan which discharges the clean air to atmosphere or building as required.

CLEANING OF SLEEVES

On top of each section is the shaking mechanism (8) which is timed so that each section is cleaned in a predetermined sequence by vertical agitation and reversal of air flow for 25 seconds every 5 minutes. In each section, the sleeves (2) are fastened to a supporting frame at the top (9) and the bottom (12); these frames are joined together by tie rods (11). The whole assembly is lifted approximately 1½ in. and allowed to fall, thus shaking the sleeves. As the assembly comes to rest, the weight of the top supporting frame (9) compresses the springs (10) momentarily, the reaction of the springs (10) imparts a sharp snatch to the sleeves, thus dislodging the fine dust adhering to the sleeves.

As the sleeves are shaking, the reverse air valve (6) is brought into position B, which opens the compartment to the atmosphere allowing air to be drawn into the compartment and through the sleeves in an opposite direction to normal flow. This reverse air current removes the light dust dislodged by the shaking from the inside of the sleeves, and carries it into the hopper below.

Chapter XX

PNEUMATIC CONVEYING IN THE COMPOUND MILL

Pneumatic conveying has been in use for about fifty years ; it is employed for the handling of grain at ports and large mill silos ; for the bulk intake of meal, although this is confined mainly to the United States, and for pneumatic delivery systems from high speed grinders. All these forms of pneumatic conveying are usually of the high pressure type; they have been described in Chapters IV and XIX, and their advantages over bucket elevators for the applications mentioned are well known.

For general purpose conveying, however, high pressure systems leave much to be desired, and many of their advantages are outweighed by their disadvantages; they take considerably more power than bucket elevators, they cause excessive dust, they have a tendency to choke when there is a variation of the input of material, and they take up much space.

For these reasons Henry Simon Ltd. have designed a ' low pressure ' system, which in flour mills is now thoroughly established, and is rapidly eliminating the bucket elevator. In compound mills, the development of this system is not so advanced mainly because of the problems involved in conveying such a wide variety of materials of different density and particle size. However, much research work is being done with various materials, and ' low pressure ' pneumatic conveying in compound mills promises to have a considerable future. Consequently, a separate chapter is devoted to this subject.

The advantages of ' low pressure ' conveying in relation to bucket elevator systems may be summarised as follows:

(1) Space is saved and neatness achieved by the slim elevating pipes which replace the bulky elevator legs.
(2) Horizontal conveying is eliminated.
(3) The reduction of moving parts involves considerably less maintenance.
(4) The risk of fire is reduced by the elimination of elevator head pulleys which are liable to cause friction and overheating.
(5) The machines are subjected to an efficient exhaust and cleanliness is assured, since it is impossible for dust to leak out into the mill.
(6) In the case of elevating from grinders the whole system is under suction, which releases the high pressure built up, cools the material, reduces the evaporation loss and ensures easy separation in subsequent sifting operations.

The Simon ' low pressure ' system incorporates a device that makes it completely chokeproof and has a power requirement very little higher than that of a bucket elevator system. The features of the system are the diffuser and the patented cyclone, together with the substantially vertical conveying pipe.

The diffuser (Fig. 180A) consists of a circular steel or aluminium alloy chamber with an inlet and outlet arranged tangentially; it is fitted with a flap at the entry to the circular chamber. In the chamber is a shaft carrying finger beaters which can be arranged for a group of diffusers; the shaft is driven by a small motor and a group of fifteen diffusers only requires 1 H.P.

The diffuser is the foundation of the low-pressure system, since it eliminates the necessity for horizontal conveying, provides a completely automatic safeguard against overloading, and reduces the power necessary to accelerate the material to its stable conveying velocity, since the rapidly rotating beaters eject the stock into the elevating pipe with a high initial velocity.

Probably the main advantage of diffuser systems is that they are completely chokeproof. If, for example, the pneumatic pipe is so designed to convey 1000 lb. of material per hour, but is fed momentarily with a feed of 1600 lb. per hour, then the automatic release flap will allow material to be discharged at a rate of approximately 600 lb. per hour, or 10 lb. per minute during the period for which the overflow is maintained. The remaining 1000 lb. per hour will be conveyed normally, the elevating pipe being unaffected.

In a high-pressure system, a temporary overload of this nature would cause a choke, which could only be freed by dismantling at least a part of the conveying pipe. Obviously this is an unsatisfactory and costly business, but it can only be avoided by designing the high-pressure lift for a capacity much higher than the one at which it will normally work. This increases the power factor to an uneconomical point. In a low-pressure diffuser system, the miller, even though he has had no experience of pneumatic conveying, is able to start up and work the plant without assistance from engineers. By successively adjusting the air control valves until no material is discharged by any of the diffusers, a satisfactory balance is automatically achieved.

The second major advantage of the low-pressure system is its low power consumption. Results show that the low-pressure system uses only approximately 42 per cent. of the power consumed by a typical high-pressure system, even when both are operating at the same 10 per cent. margin above the minimum conveying velocity. This margin is a very difficult condition to attain in practice with the high-pressure system, since a small feed fluctuation would then cause the pipe to choke. In fact, it is considered that an operating margin of 20 per cent. is the minimum practicable for a ' non-diffuser ' system, and on that basis the low-pressure system requires only 36 per cent. of the power required by the high-pressure system.

As illustrated, in the low-pressure system the material falls from a machine down an inclined spout, along which the conveying air, having passed through and exhausted the machine, is also drawn. The revolving beaters of the diffuser flick the material upwards and throw or ' diffuse ' it into the vertical air stream without any appreciable loss of pressure. When the plant is working at its designed capacity, the diffuser flap is kept closed by the pressure of the outside air. If there is a sudden increase in the flow of material, the flap is forced open by the additional weight.

The material is elevated from the diffuser to the desired height, and it is then separated from the conveying air by the patented cyclone (Fig. 180B),

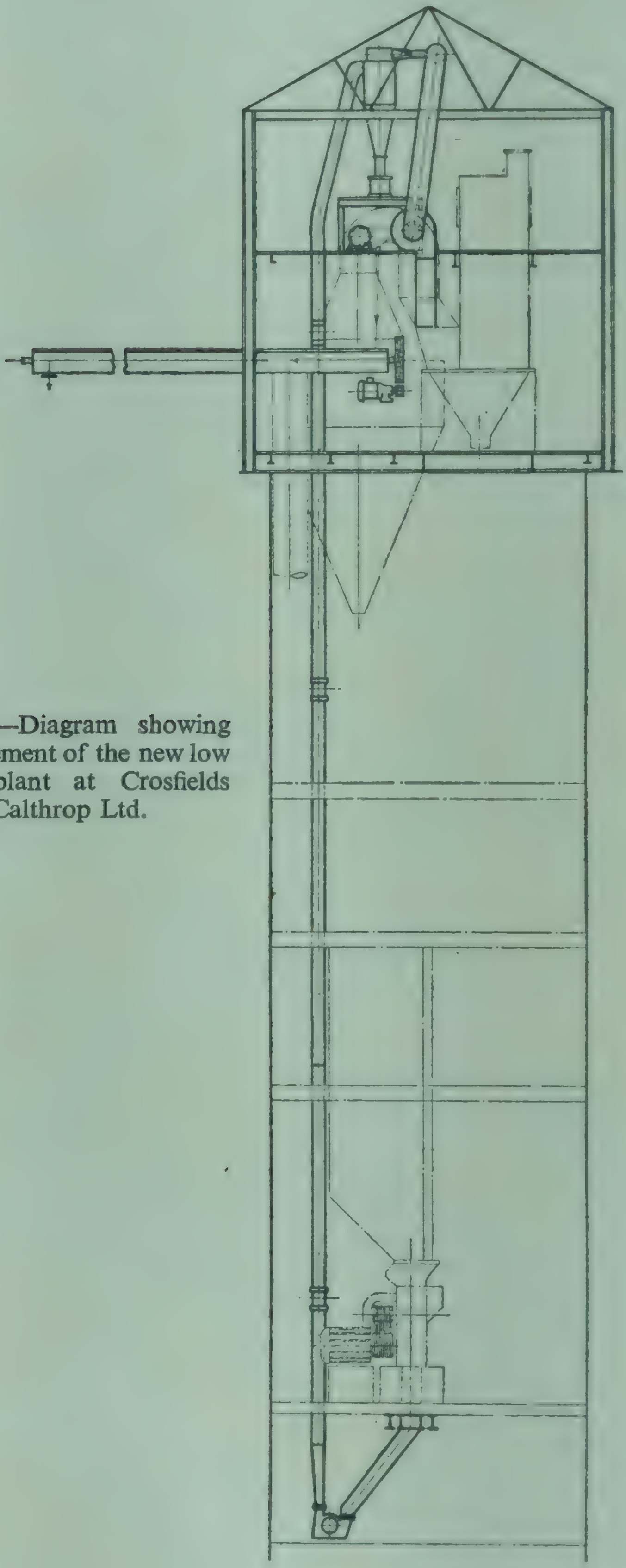


FIG. 182.—Diagram showing the arrangement of the new low pressure plant at Crosfields & Calthrop Ltd.

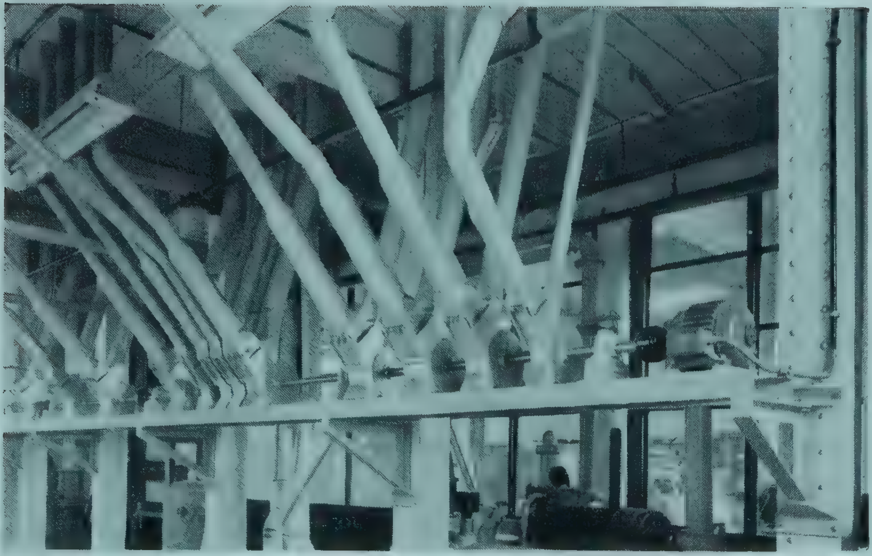


FIG. 181A.—Diffusers and spouts in the basement of Simon experimental mill at Cheadle Heath, Cheshire.

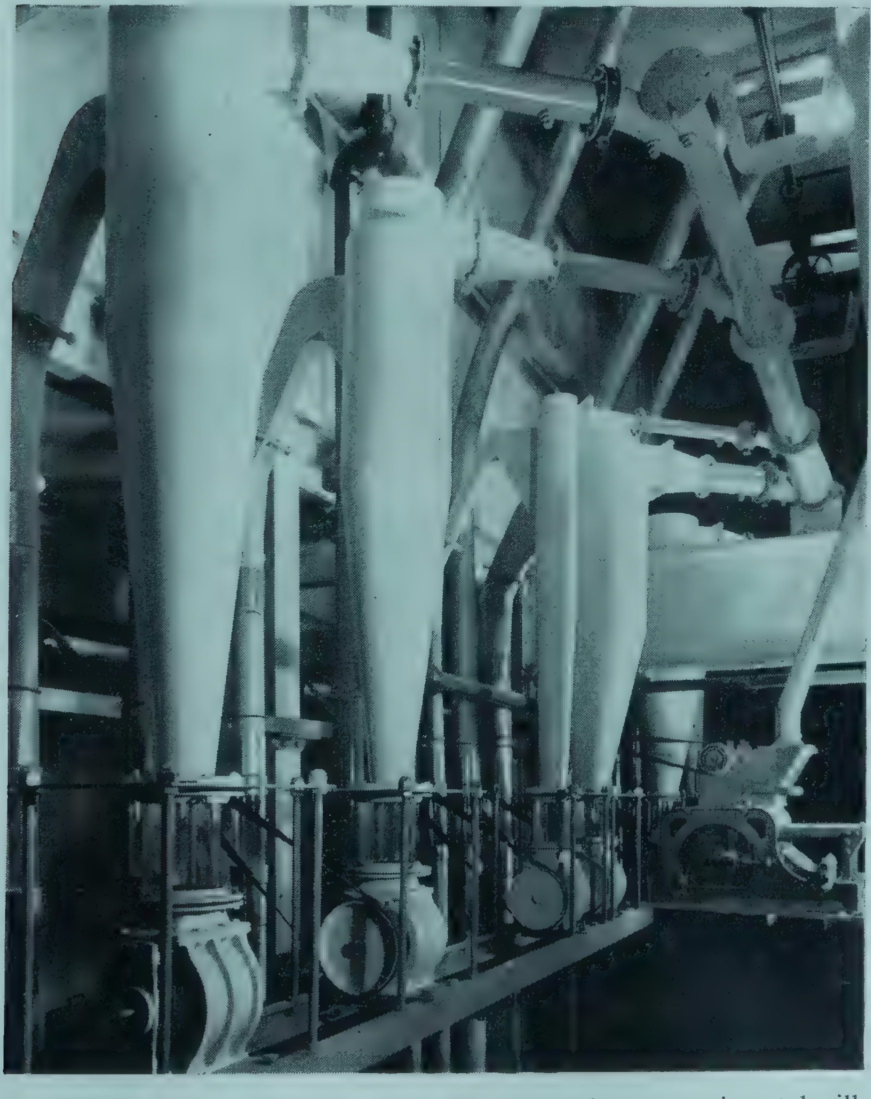
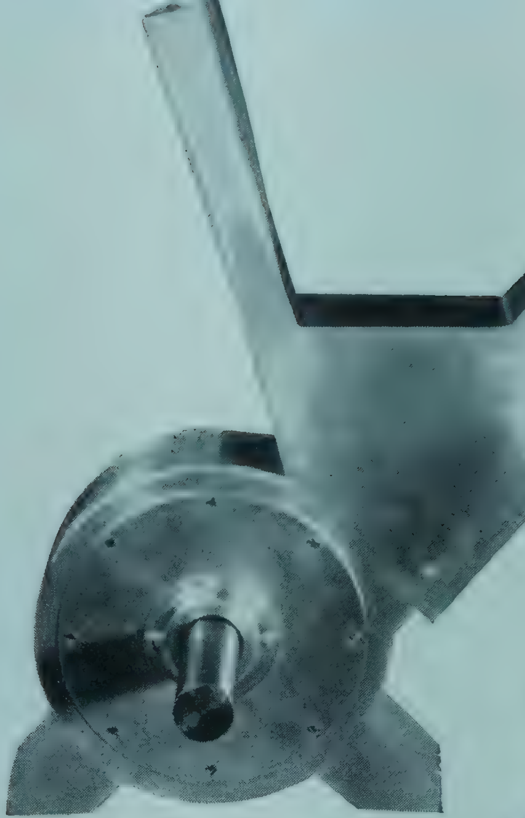


FIG. 181B.—Some of the cyclones installed in the Simon experimental mill.

Fig. 180A.—The Diffuser. The inlet is on the right, with the release flap just below.



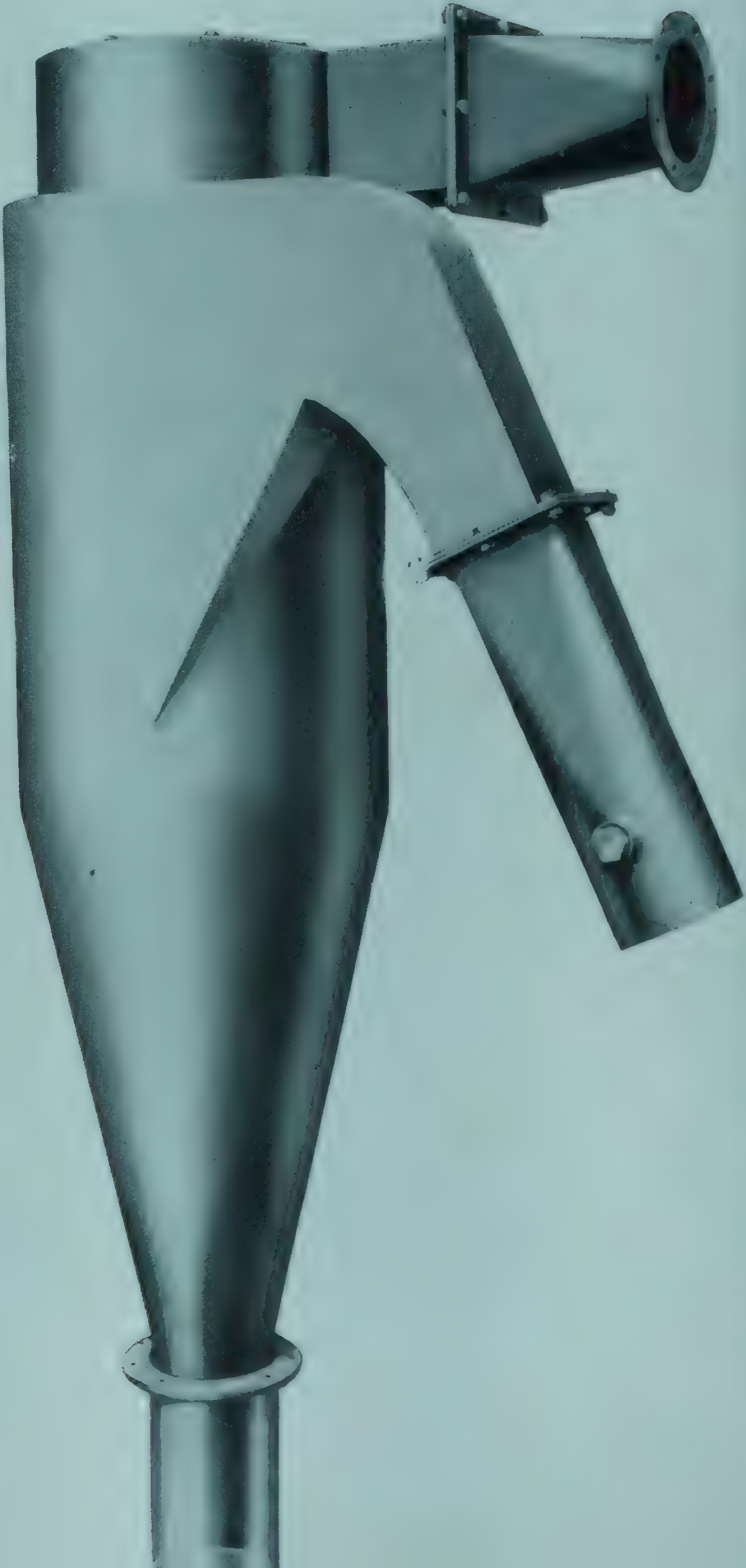


Fig. 180B.—The Cyclone, specially developed for low pressure conveying.

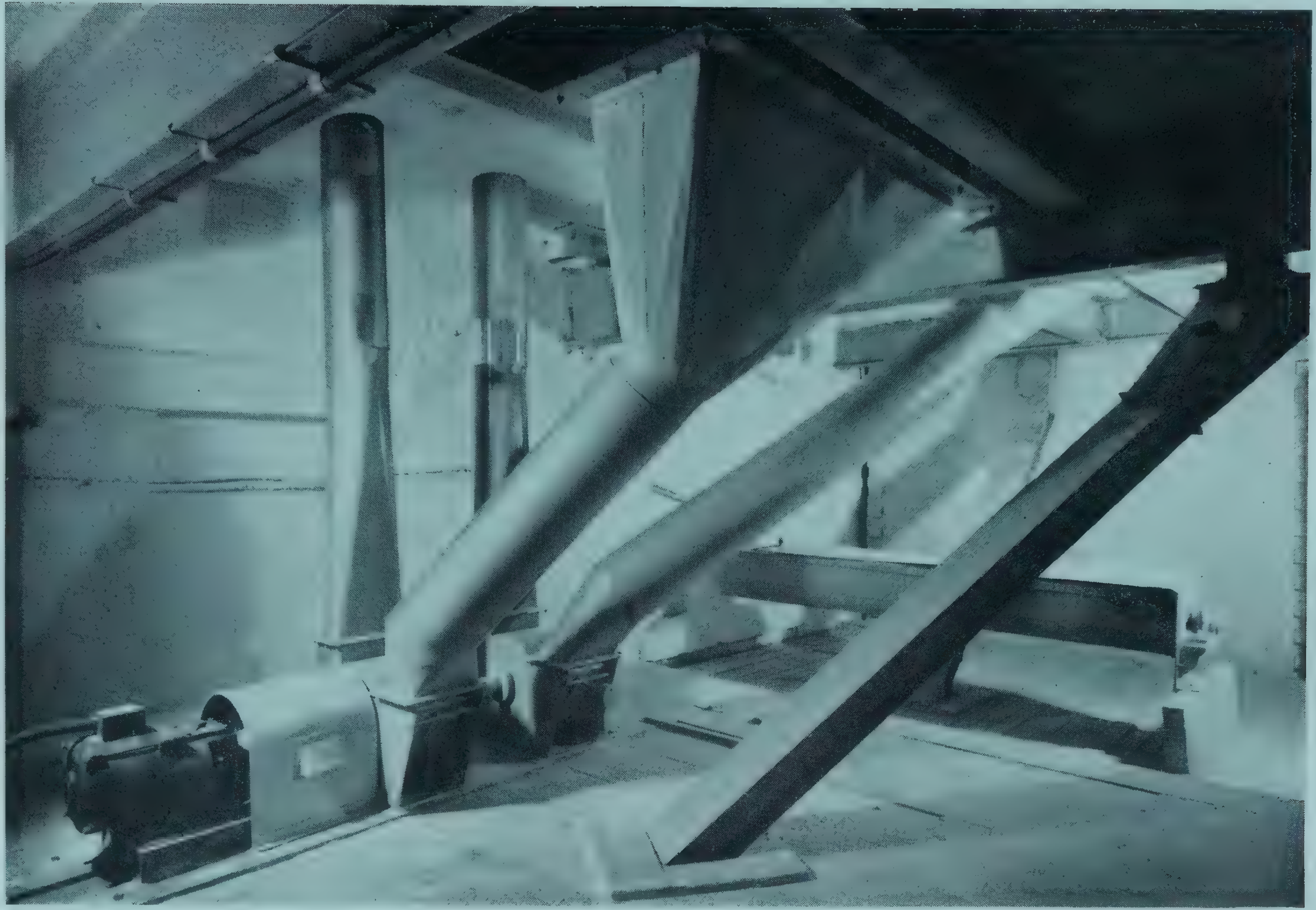


FIG. 183.—A view of diffusers in which their common driving shaft and the release flaps can be seen.

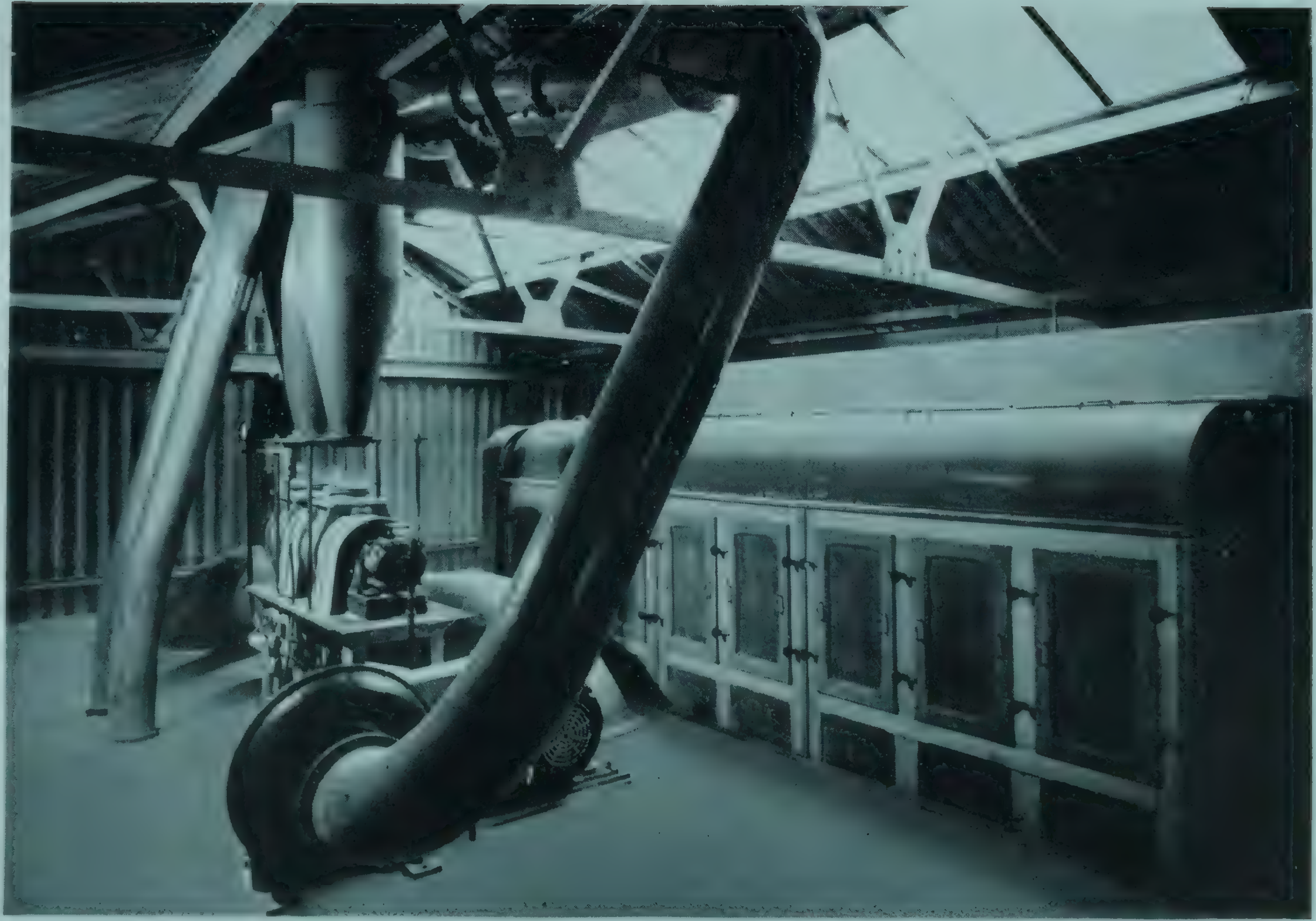


FIG. 184.—The cyclones, fan, and dust collector at the head of the low-pressure lifts.

which has been designed specifically for use in the ' low pressure ' system. The chief feature of the cyclone is the inlet, which is practically vertical. Therefore it can be connected to the vertical conveying pipe without the bend and the horizontal section required by a conventional cyclone, which is always a source of pressure loss and chokes.

The substantially vertical lift is a most important feature of the ' low pressure ' system because a vertical lift is more economical than one combining vertical and horizontal conveying. This is due to the fact that the critical velocity in a horizontal pipe is considerably higher than in a vertical one of the same size ; it means that a vertical conveying line consumes substantially less power than one in which the material has to be carried along a horizontal pipe. The diffuser and cyclone have been designed with this in mind.

Figs. 183 and 184 show a low pressure installation recently installed by Henry Simon Ltd., at Messrs. Crosfields and Calthrop Ltd. In this case, the ground meals are elevated to a height of 67 ft. from two Barron Impact Grinders. The meals, after being separated from the air by the two special cyclones, pass through a seal and worm conveyor to the meal bins. The air is blown by a fan to a Simon Suction Filter Dust Collector, which is also used for exhausting other machines in the mill. The large standard cyclone dust collector shown in the diagram (Fig. 182) is part of the general mill exhaust system, and is installed immediately before the Suction Filter Dust Collector. This cyclone separates the heavy dust and so relieves the work of the Suction Filter.

Chapter XXI

WEIGHING AND PACKING OF FINISHED PRODUCTS

It is convenient to consider the weighing and packing of finished products under three headings, as follows :

(1) The hand weighing method.
(2) The gross weigher method.
(3) The net weigher or fully automatic method.

(1) THE HAND WEIGHING METHOD

Bagging-off Spouts

This is the simplest method and is used by smaller compound and provender millers. The bagging-off point consists of a mild sheet steel, cast iron or wooden spout which, especially in the case of cubes and pellets, is often part of or immediately preceded by a small reserve hopper. The bottom of the spout is fitted with a cast iron or wooden ring to which the bag is attached by a leather strap with a quick release buckle. When the rate of filling is over 2 tons per hour, twin packing-off points should be used to give the packers more time for changing bags.

When the bag is full, a slide is closed and the bag is removed by hand on to an adjacent portable platform scale and weighed. In compound milling, bags are usually sufficiently large to eliminate the necessity for mechanical possers, although, while the bag is filling, a certain amount of knee possing from the operator may take place. For this reason, sacking-off spouts should be rigidly fixed to their supporting structure to allow for the weight of the swinging bag and they should preferably be constructed of sheet steel.

Although mechanical possers are not necessary for meals, cubes and pellets, they are sometimes an advantage for bulky flaked products, because flakes should be tightly packed to prevent breakage in transit, and the possing action does not break them.

Sack Grips

The ordinary leather strap and quick release buckle for attaching the bag on to the bottom ring of the spout, requires two hands and is rather clumsy to use. A quicker and easier method is to use a sack grip which can be operated by one hand, such as the Avery ‘ Rapid ’ Grip. It consists of a metal clamp with an adjustable balata belt and two rigid jaws hinged at the back, which close upon the bag by a reverse movement of a one-hand operated lever. This leaves the other hand free to hold the bag.

Slides

In hand weighing, efficient slides in the spouts play an important part, and greatly assist the packer in his work. A metal slide, with a turned up end, is difficult to extract as meals tend to jam up the slide tracks. A much better grip is obtained with a wooden slide cut away at the holding end, and fitted with a circular grip so that the operator can insert his hand.

Platform Weighers

There are three types of platform scales used in hand weighing; the ordinary steelyard platform scale with a sliding poise weight; the platform dial type, in which the movement of the weighing levers under the platform is transmitted to a pointer traversing a graduated scale, and a similar type that indicates correct or plus and minus weights.

The second type is usually calibrated in 4 oz. graduations from zero to 2 cwt. and indicates the full weight of the bag placed in the platform.

The third type is provided with an adjustable pre-weight lever arrangement, so that the weight required can be pre-set to indicate on the dial either as correct or plus or minus. The platforms in all these types are supported on lever and knife edge systems.

With the two dial types, the weighers can be placed immediately underneath the packing off spout so that the bag rests on the platform, thus avoiding the necessity of moving the bag to the weigher. The bag is held open by a stand and clips fixed to the platform. The packing-off spout, which should be wide and suitably inclined, is fitted with a slide and delivers directly into the bag. The slide can then be adjusted sensitively as near as possible to the exact weight of the weigher dial without having to use a hand scoop. This method is not often used because it is dusty in operation.

(2) THE GROSS WEIGHER METHOD

In this method, the bag is attached to the weigher beam mechanism and the total weight is made up by the material and the weight of the bag. The total weight of the material is not weighed automatically, the last pound or two having to be fed in by the operator. This method is particularly favoured by compound and provender millers because it is simple and much quicker than the foregoing, thus reducing the labour cost per ton of material weighed. Also, the weighers are inexpensive in relation to fully automatic net weighers.

The Combined Automatic Weigher and Check Scale

A machine of this type suitable for compound millers is manufactured by Richard Simon & Sons Ltd. for the weighing of meals, cubes and pellets, as illustrated in Fig. 185. In this machine, up to three bags per minute can be filled but the speed and accuracy of weighing depends to a large extent on the skill of the operator.

The operator attaches the empty bag to the spout, opens the feedgate and the bulk of the material is then fed into the bag. When the weight is about 2 lb. less than the predetermined amount to be weighed, the feedgate automatically closes. The operator then makes up the exact weight by means of a hand operated inlet valve.

The Avery Gross Weigher

This machine made by W. & T. Avery Ltd. (Fig. 186) for weighing meals, cubes or pellets, is similar in principle to the above. The illustration shows the packing floor of a large compound mill.

THE FULLY AUTOMATIC GROSS WEIGHER

Another gross weigher made by Richard Simon & Sons Ltd. for meals, cubes and pellets (Fig. 187) operates in a similar manner to the above except that after the main feedgate has closed, a vibrator feeder makes up the exact weight instead of the hand operated inlet valve. The accuracy of the machine, which weighs up to three bags a minute, is, therefore, automatically controlled.

(3) THE NET WEIGHER OR FULLY AUTOMATIC METHOD

In this method, the bag is attached to a hopper underneath the weigher beam mechanism and weigh pan and the net weight of the material is automatically and accurately weighed. The weighers are more accurate and much larger quantities can be weighed than by the gross method; they are mainly used in the largest type of mill.

Fig. 188 shows a fully automatic ' Reform ' weigher manufactured by Henry Simon Ltd., which is suitable for meals. The feed hopper consists of a rectangular chamber and two sets of stirrers which assist the flow of material to the weigh bucket, thereby evening out the fluctuations of the incoming flow of material. The weigher itself works on the same principle as that already described for the intake of grain.

The weigh bucket discharges the exact amount of material required into a hopper to which the bags are attached by a quick release strap, each tip being recorded automatically on a counter. The machine is completely enclosed and dustproof. The photograph shows the bag resting on a ' Reform ' platform posser which is referred to on page 245.

Another type of fully automatic ' Reform ' weigher is manufactured by Henry Simon Ltd., suitable for cubes, pellets, flakes and other materials which do not flow freely. It is designed to give gentle treatment to avoid excessive breakage. A short conveyor band is used to feed the material into the weigh bucket, a deep weigh bucket being used to accommodate bulky flaked products.

The conveyor band, driven through a flat belt by a back geared motor, is arranged to stop as the weigh bucket receives a full weighment, and to re-start when the bucket door has closed, the band driving pulley being pivoted on an arm and pulled out of contact with the belt by means of the solenoid. The solenoid is energised by a switch actuated by the weighing mechanism as the machine completes its weighment. The reverse action takes place as the weighment is discharged.

The Richard Simon fully automatic weigher (Fig. 189), suitable for cubes and pellets, incorporates the usual type of weigh beam and weigh pan but the material is automatically fed into the machine by two vibrator feeders; one feeds the bulk of the material and the other the dribble feed. This machine is suitable for weighing up to five times per minute.

Another Richard Simon weigher, known as the AE type, is of similar design but is normally used only for pellets and other free flowing materials.

This machine may be adapted, however, for materials, which do not flow freely, and it is then supplied with a feeding mechanism consisting of a totally enclosed belt feeder which feeds the majority of the material into

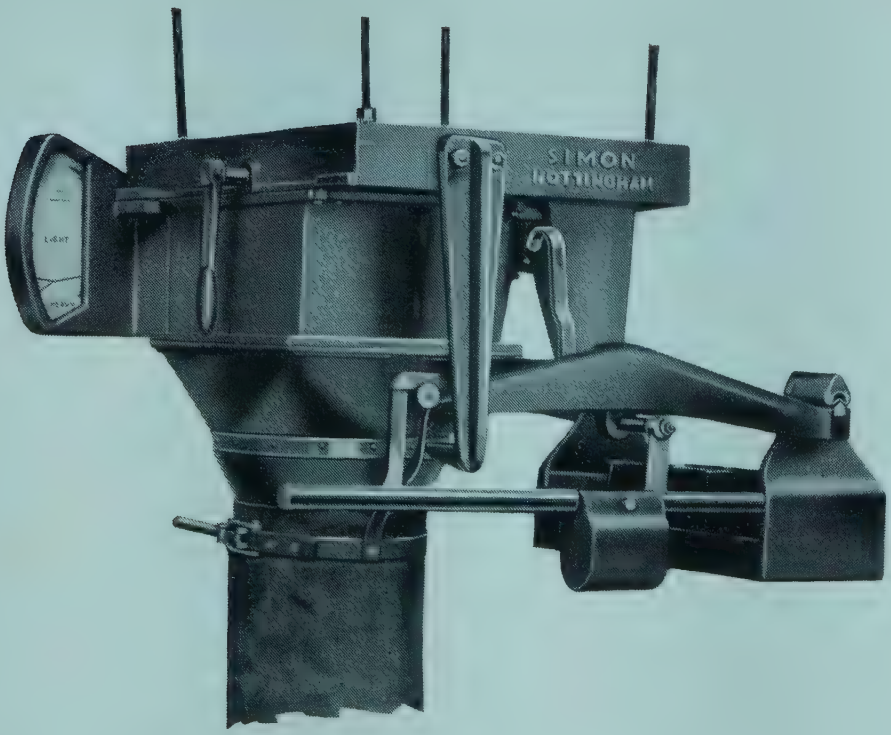

SIMON
NOTTINGHAM

FIG. 185.—Richard Simon semi-automatic gross weigher.

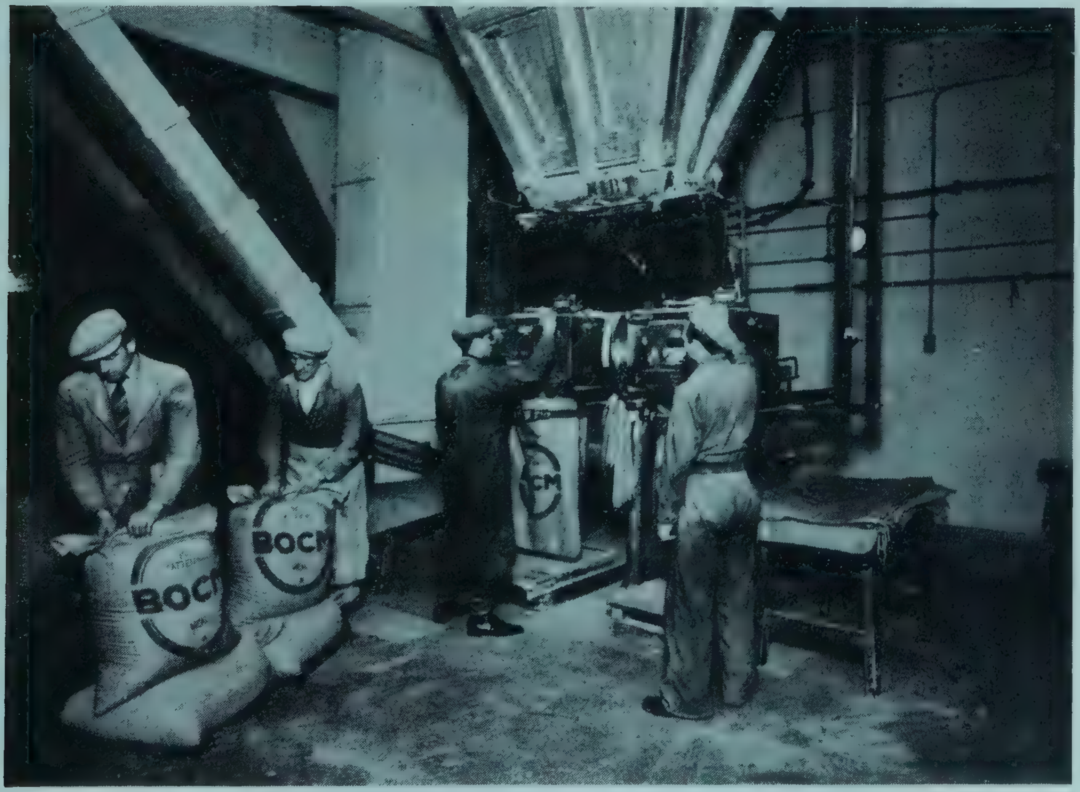


FIG. 186.—Packing compounds with Avery gross weighers.

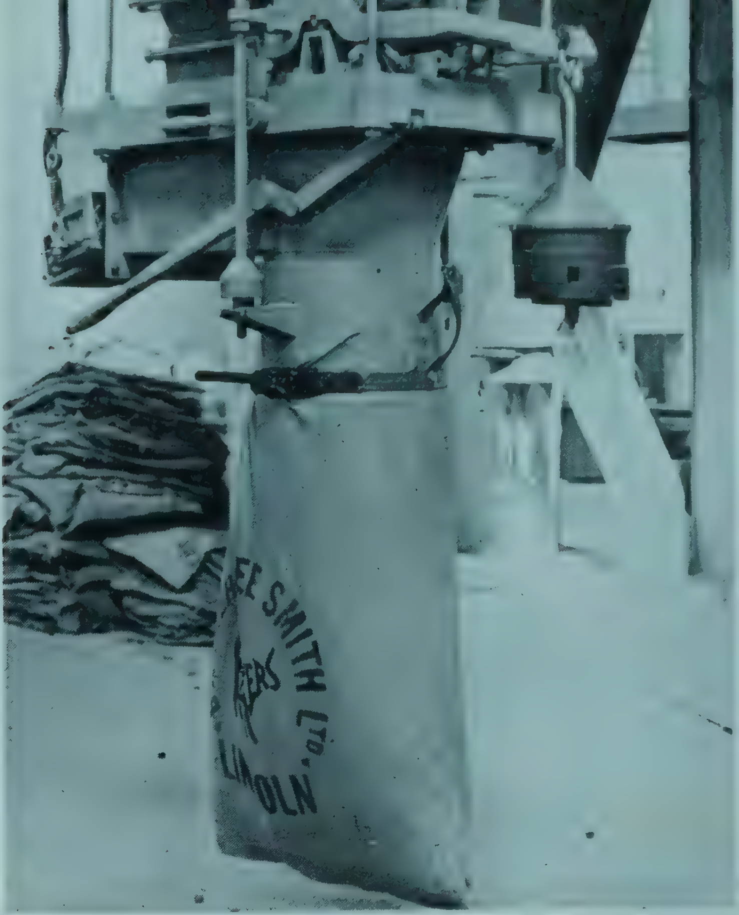

SMITH LTD.
LINCOLN

FIG. 187.—Richard Simon fully-automatic gross weigher.

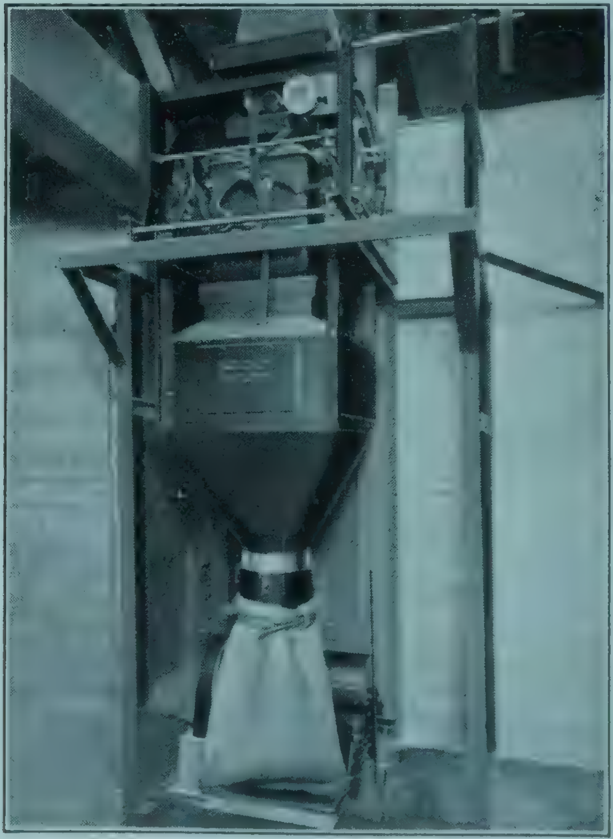


FIG. 188.—H. Simon fully-automatic 'Reform' weigher.

the weigh hopper. An automatically operated slide then reduces the feed to a dribble and, when the exact weight is in the weigh hopper, the belt is brought to rest by an electro-magnetic brake. This machine is capable of making up to six discharges per minute.

The Avery net weigher is similar to the gross weigher except that it is fitted with a vibrator to make it fully automatic when working on cubes and pellets.

PACKING AND BAGS

1. MECHANICAL POSSERS

Mechanical possers used in the hand weighing method are of various types and may be outlined briefly as follows :

The simplest type consists of a sliding ring to which the sack is attached and which is moved up and down at about 60 strokes per minute over a circular metal spout through which the material passes into the bag; the sliding ring is oscillated by a crank pin and pivoted lever, the pin being adjustable according to the severity of the possing required.

Another type known as the ' Reform ', which may be used in conjunction with gross or fully automatic weighers, as shown in Fig. 188, consists of a pivoted platform on which the base of bag is placed, the top being connected to the sacking off spout or hopper. A pulley driven cam and roller mechanism repeatedly oscillates up and down the platform. The possing action may be started and stopped by a conveniently placed lever, which moves the roller arm into or out of the path of the lifting cam, no clutches or belt shifting gear being necessary. Pedal control may be fitted instead of a lever.

2. TYPES OF BAGS FOR COMPOUND AND PROVENDER PRODUCTS

(*a*) *Hessian Bags*

The coarse cloth bags, in which the majority of compound and provender products are packed, are made from jute or hemp and are known as hessians. They vary in texture and in size according to the nature of the product as follows :

(1) Cubes, pellets and most meals are usually packed in 140 lb. bags of thick texture measuring 40 in. × 28 in. or sometimes 45 in. × 25 in., or in 112 lb. bags measuring 43 in. × 24 in. Cheaper thin texture bags may also be used for some grades of cubes and pellets.

(2) Flaked maize, bran and other bulky products are packed in 112 lb. bags, measuring about 56 in. × 28 in., of thin texture to allow for circulation of air.

(3) Poultry corn of all kinds is usually packed in 112 lb. bags of thin texture measuring about 36 in. × 26 in.

(*b*) *Paper Bags*

Paper bags are also sometimes used, but usually only for poultry and pig meals, grass meals or grass cubes. There have been many arguments for and against the universal use of paper bags, but the fact remains that they have not yet been generally accepted in the trade because their advantages are usually cancelled out by their disadvantages.

Their advantages are :

(1) They are cheaper than hessian bags.
(2) There is less risk of disease being carried from one farm to another because the bag is only used once and is then destroyed. It is for this reason that they are often used for poultry meals because poultry are particularly subject to disease.
(3) They are less subject to damage from vermin.
(4) They look attractive when new, particularly when branded with coloured trade marks.
(5) The miller need give no second-hand credit.

On the other hand the disadvantages of paper bags are :

(1) They are more likely to be broken during handling and particularly when affected by wet weather. The oil in meals is liable to soften the paper in storage, which causes the bag to split when handled.
(2) They have no second hand value and are no use to the farmer as a cheap bag as in the case of second hand hessians.
(3) Their impervious nature prevents any excessive heat and moisture escaping from the bag, and in order to offset this their contents must be cooler and drier than in the case of hessians.
(4) Paper bags are difficult to grip during handling, but handling may be facilitated if they are packed in ½ cwts.

3. THE WEIGHT OF BAGS

Compound and provender products are usually sold to farmers by gross weight with the bags included, an allowance of up to 2½ lb. being made according to the thickness of the bag. The bag is charged for, the charge being deducted if the bag is returned.

4. BAG PRINTING

Many large millers have their name and trade mark printed on their bags together with the weight, type of product, and sometimes the analysis. Owing to the large range of compound and provender products, it is an asset for a miller to have his own bag printing department, otherwise a large stock of different kinds has to be carried in case of emergency. If the miller has his own printing machines he can print or alter any kind of bag at short notice. Fig. 190 shows a typical installation.

5. TYING AND SEWING OF FILLED BAGS

A large number of bags are closed by tying the mouth with string or wire. In many cases, however, especially with compounds, the filled bag is stitched either by hand (Fig. 186) or by special sewing machine (Fig. 189) which improves the appearance and makes it absolutely secure. In the latter case, the bagged products are placed direct from the weighers on to a small carrying conveyor, which conveys them to the sewing machine. These machines are adjustable according to the height of the bags, the mouth of the bag being guided by hand through the stitching arm as it is conveyed. Modern sewing machines save a considerable amount of time and labour

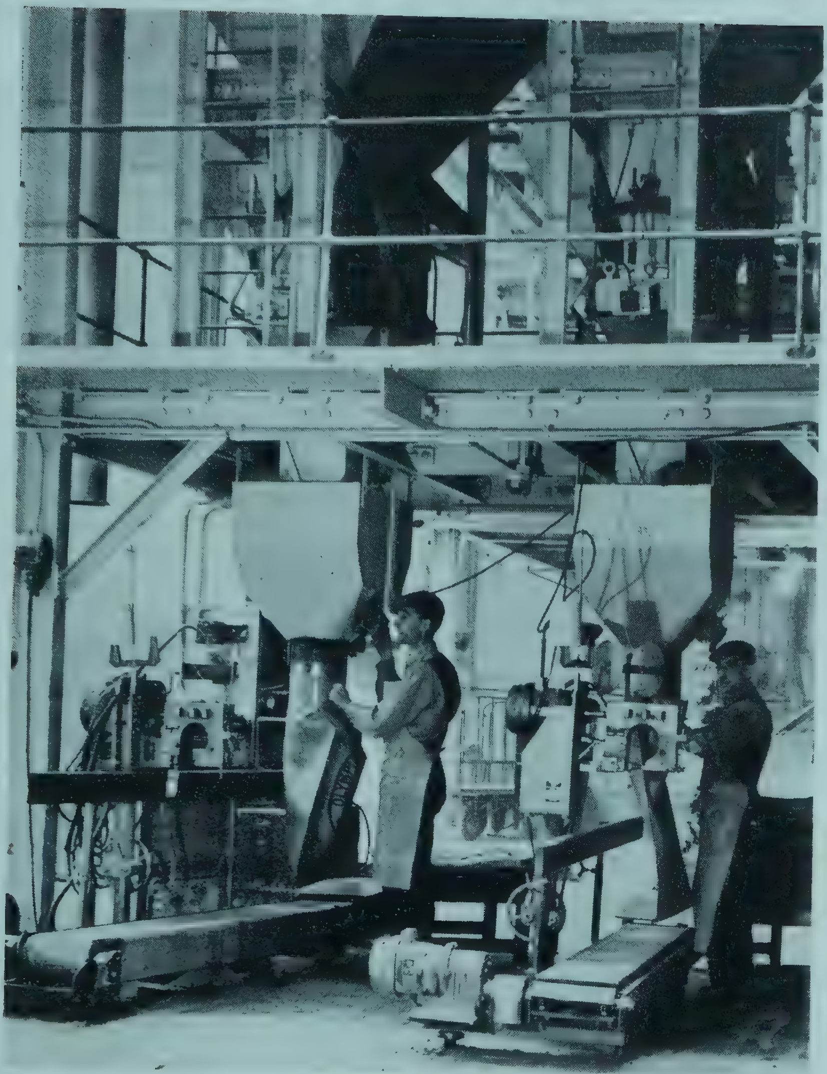


FIG. 189.—Richard Simon fully-automatic net weigher.

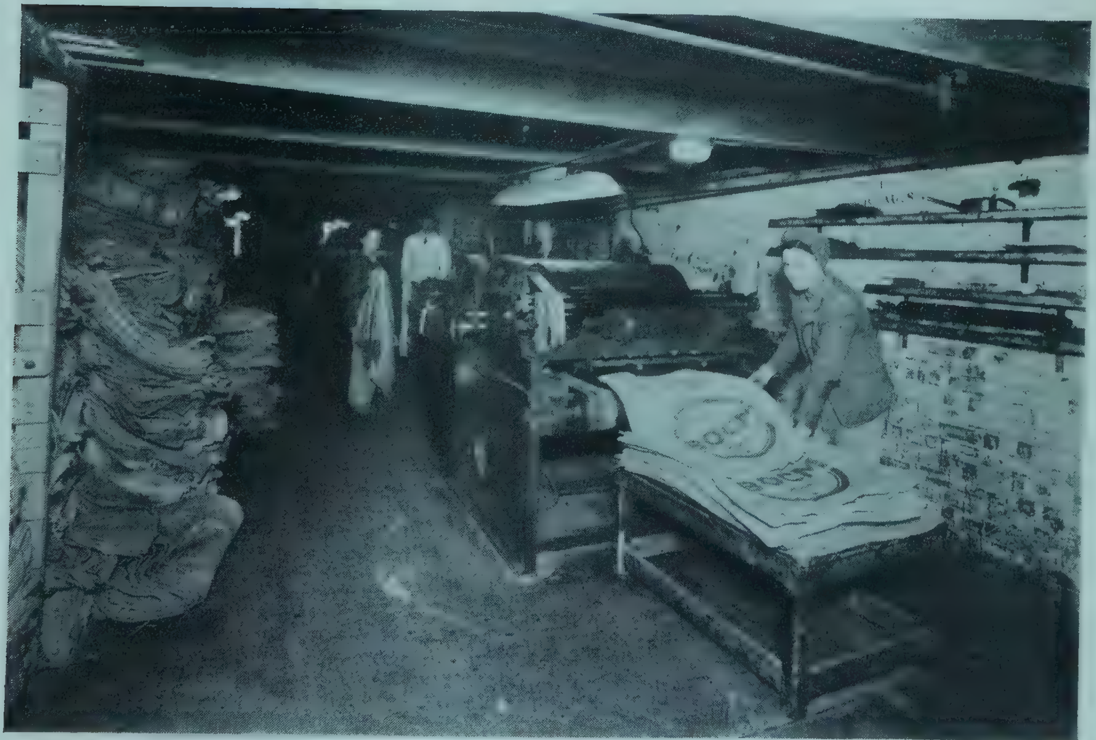


FIG. 190.—Bag printing in a large mill.

compared with the hand sewing method; they are mounted on a carriage, which can be moved into any desired position, and are driven by a self-contained motor.

The Fischbein portable sewing machine supplied by the Thames Sack and Bag Co., Ltd., is much simpler than the conveyor type and, therefore, is more suitable for smaller millers. This compact unit is drawn across the top of the bag by hand, its weight being taken off the operator by a cord suspended from above it ; it is capable of stitching three bags per minute.

6. Labelling and Checking of Bags

A printed label carrying the serial number, type of product, and the analysis is tied or sewn on each bag. The packer keeps a tally sheet, which is collected and checked against the serial numbers by the charge hand or foreman at the end of each shift, and is then sent to the office for entry on the daily or weekly stock sheet. This enables the miller to keep accurate records of the age of the products, and, in case of complaint by the customer, he is able to turn up the exact date of manufacture. A system of coloured strings, each colour denoting a certain period, is also very helpful for quick assessment of the date of manufacture of any particular product.

The correct method of entering the number of bags on the tally sheet is to make five strokes, one for each bag, with four upright strokes and one diagonal stroke in the form of a five-barred gate. This enables the strokes to be easily added up and checked.

7. Cleaning of Bags

The thorough cleaning of bags in compound and provender mills is important not only because of the saving of material clinging to the corners and weave of the bag, but because it is easier to repair it for re-use.

The best method of cleaning bags is by the use of pneumatic cleaners. In the Barron method, the dirty bag is held by the top under a suction tube, the air current from a fan pulling the bag into the tube and at the same time turning it inside out. The bag is then withdrawn by the operator and the same process repeated so that the bag is again the right side out. A bar grid prevents the possibility of the bag being drawn up into the fan.

The extracted material from the bags is blown by the fan into twin cyclone separators, where the heaviest dust settles and is bagged off from the bottom. The air escapes through the dust chamber and fabric sleeves from which any light dust is withdrawn periodically.

Chapter XXII

STORAGE AND DELIVERY OF FINISHED PRODUCTS

1. Bulk Storage of Finished Products

In this country, the bulk storage of finished products in compound and provender mills lends itself mainly to the storage of straight processed meals, which are either to be sold direct, or stored in readiness for admixture into compound rations. Compound meals are seldom stored in bins of any size, partly owing to their tendency to grade into particle sizes, which unbalance the ration, and, partly, because the majority of compounds contain molasses, and are, therefore, sticky, and flow unsatisfactorily from bins. Cubes and pellets also tend to stick in bins, if stored for any length of time, and, at present, are not often bulk stored except in a few countries, as, for example, in Denmark, where the cubes resemble a mixture of kibbled cakes in composition and free flowing characteristics.

Bran and weatings may be bulk stored, particularly in the case of compound mills attached to flour mills, when the bran and weatings may be conveyed direct from the flour mill to the range of process bins for a semi-continuous or continuous compound plant.

The advantages and disadvantages of bag and bulk storage are discussed in the chapter on raw materials, but an advantage of bulk storage for finished products not previously mentioned is that labour for packing may be saved during night shifts. In this way, the bins may be filled at night without packers, and warehousemen may help the day packers empty the bins during slack periods between the loading and unloading of wagons. Also, a gang of warehousemen may empty the bins, bag the products, and load direct on to the wagons, thus saving double handling and stacking.

It should be noted that finished products that are bulk stored remain static until discharged and, therefore, will pack and arch more tightly than materials in process bins which are constantly on the move. Finished products, therefore, should not normally remain in a bin more than twenty hours, particularly if they have a high moisture content. For these reasons, by far the greater part of finished products in compound and provender mills in this country are stored in bags.

2. Bag Storage and Delivery in Small Mills

In the smaller mill of some 200-300 tons per week output, having three or four floors, the best arrangement is for the finished products to be packed off on the first floor of the mill because this is the most convenient height for delivery to road or rail wagons. This floor should be used as the main storage floor and, preferably, it should be extended to a warehouse on the same level because, if it is sufficiently large, handling from other floors is saved.

If the mill is alongside a public road, a hinged loading door or platform may be used which is drawn up when the mill is closed at night. On the

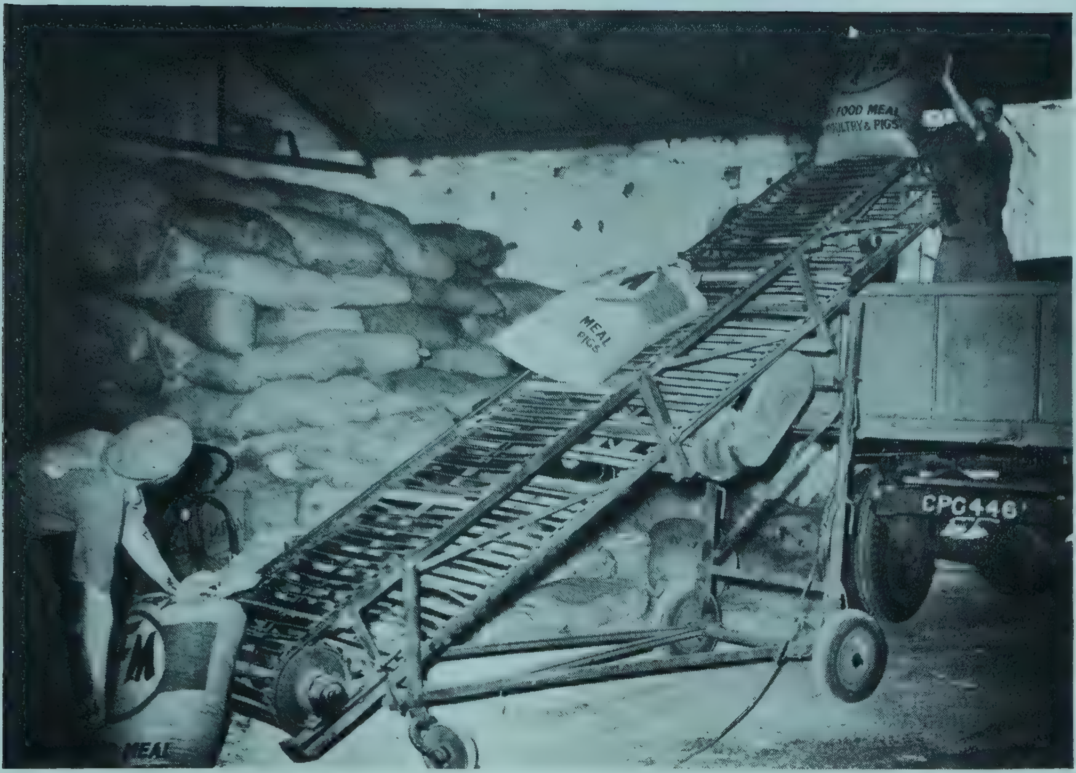

FOOD MEAL
POULTRY & PIGS
MEAL
PIGS
CPG446
MEAL

FIG. 191A.—Inclined sack conveyor delivering finished products from ground floor of mill.

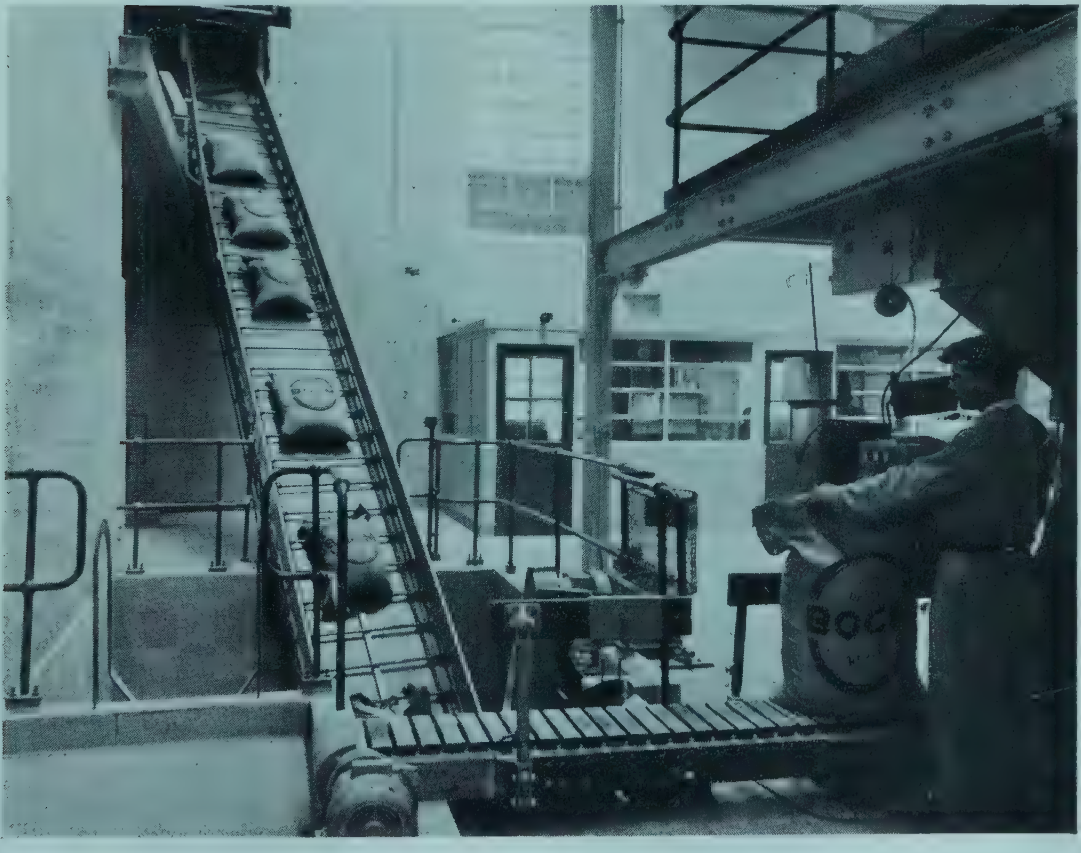


FIG. 191B.—Inclined sack conveyor delivering finished products to warehouse conveyor.

other hand, if there is a private yard which can be closed at night, the whole loading floor may be left open, enabling fixed loading platforms to be used.

The packing off spouts should be arranged so that they are within minimum trucking distance of the main storage accommodation and accessible to the loading out platforms. As little machinery as possible should be placed on this floor and, where trucking takes place, maple floors should be installed with the grain running in the direction of the traffic. Hand trucks should be fitted with rubber wheels. Reserve storage space may be utilised by shooting the finished products on to the ground floor, which normally contains only the elevator boots of the plant. The finished products may then be loaded out from the ground floor by a hand operated sack lifter or portable inclined bar conveyor (Figs. 191A and 191B). Alternatively, they may be elevated to the first floor by friction hoist or sack elevator.

A double hand operated sack lifter for raising sacks to shoulder height either for loading a lorry from a ground floor, or for storing the sacks in tiers, is made by Richard Sizer Ltd. The machine is power driven and provided with two platforms instead of one, as for the ordinary sack lifter, one platform being in the raised position, whilst the other is in the lower. A bag is placed on the lower platform, the bag's weight causing the platform to drop an inch and trip a switch thereby automatically making it ascend, the other platform descending to the bottom. Until the bag on the top platform is removed, the bottom platform will not ascend.

3. Bag Storage and Delivery in Large Mills

Figs. 192 and 193 show a layout of a multi-floor warehouse in a large mill. As outputs increase, the first and ground floors become insufficient for the storage of finished products, and even if the floors are extended, the distance which the products have to be conveyed becomes uneconomical. Therefore, in larger mills, although the first floor is still used as the loading floor, the packing off points may be raised from the first floor to a higher floor, and in the case of the largest mills, to the top floor. This means that all the intermediate floors and the loading floor are available for storage and receive the finished products by gravity from the higher floors with a minimum of labour and handling.

Spiral metal chutes, made up in sections riveted together round a central tube, are used for delivering bags by gravity. They may be of the single type or the double type. Straight chutes, although often used, are not so practical, except in the case of short chutes, owing to the space which they take through the necessity of having a horizontal section at the bottom to slow down the speed of the sacks.

Spiral chutes usually deliver to a loading table situated below the loading floor and at a convenient height for the carter to load the sacks on to the road or rail wagon. The loading tables may be permanently fixed to an external wall or hinged to a floor stand as desired. The whole loading floor may be open on either side to road or rail respectively, the wagons being parked in a covered way while loading.

This system lends itself to the grouping of packing off spouts, and a series of band conveyors may be arranged on any floor from the spiral chutes to distribute the sacks over the widest possible area without hand trucking.

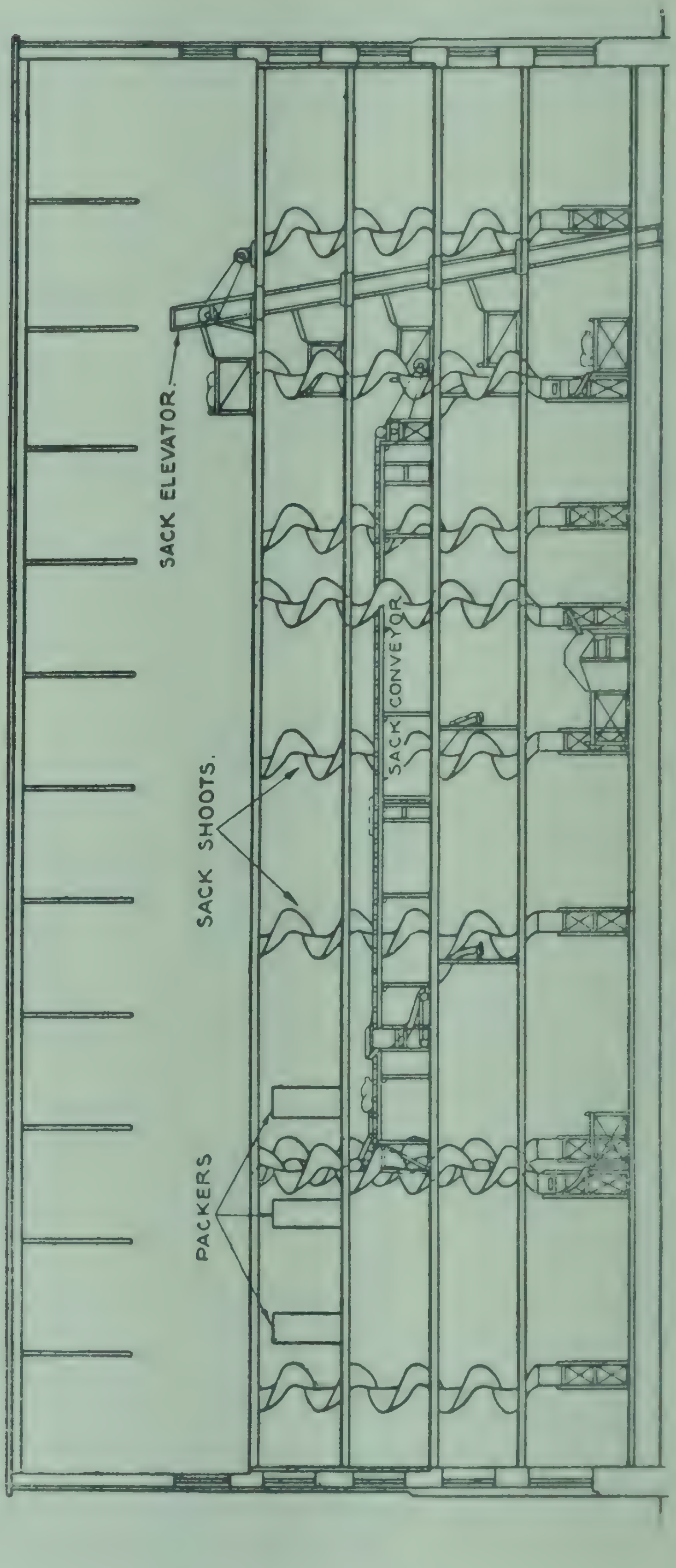

SACK ELEVATOR.
SACK SHOOTS.
SACK CONVEYOR.
PACKERS

FIG. 192.—Layout of multi-floor warehouse.

There is also the question of distributing the sacks to a number of delivery points either to rail, road or barge so that a number of vehicles can be loaded at the same time. The sacks may then be ploughed off from a band conveyor running parallel to the road or rail track to any desired wagon by adjustable diverting boards or throw off carriages. The loading rate may be adjusted by stopping and starting the band conveyors with push button control so that the sacks pile up in the spiral chutes until required. Sack conveyors may also be of the bar type, which run on side rollers and pass over two end chain sprockets.

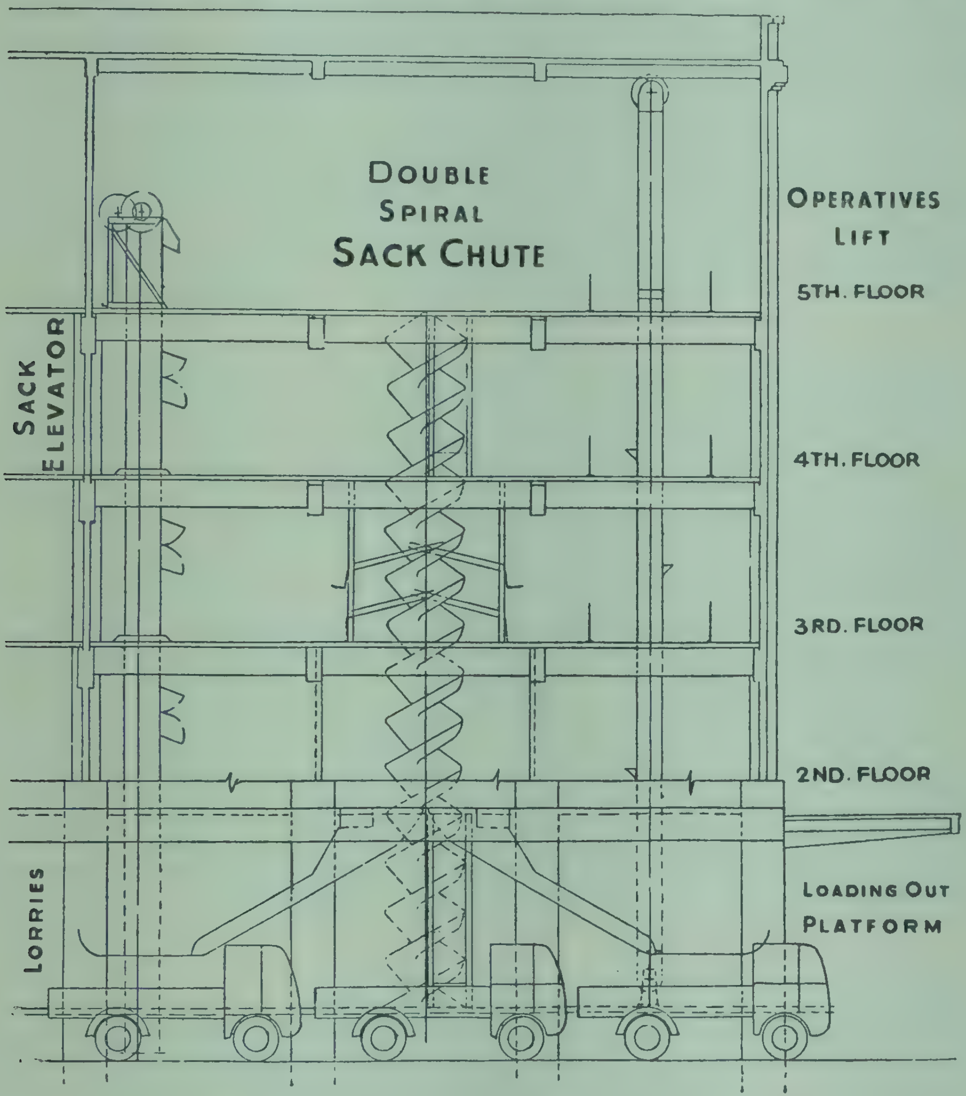


FIG. 193.—Layout of multi-floor warehouse.

Although vertical or inclined sack elevators are largely used for the intake of raw materials, they may also be used for the redistribution of finished products from lower floors in multi-floor warehouses, particularly where it is not possible to arrange for the packers on the top floor. They may be usefully employed for elevating some bagged finished products, such as cubes and pellets, which are liable to some damage by bulk elevating even when cooled. Figs. 194A, B, C show loading bays of large mills and methods of delivery to lorries.

4. The Large Single Storey Warehouse

In some compound mills, the finished products warehouse is of the single storey type as sometimes used for raw materials, in which the bags may be stored flat in tiers, the number of tiers depending on the moisture content. Portable mechanical pilers are used in this type of building.

A system of conveyors on the lines just described may be used. A warehouse of this type is usually rectangular, with two long and two short sides, to enable a number of road or rail wagons to be loaded at the same time along its longest sides. The conveyors are arranged longitudinally to the opposite ends of the building with return strands, which deliver the bags by means of ploughs or diverting boards at any desired point. In this system, the maximum amount of carrying or trucking necessary is reduced to half the width of the warehouse.

5. Automatic Delivery Systems

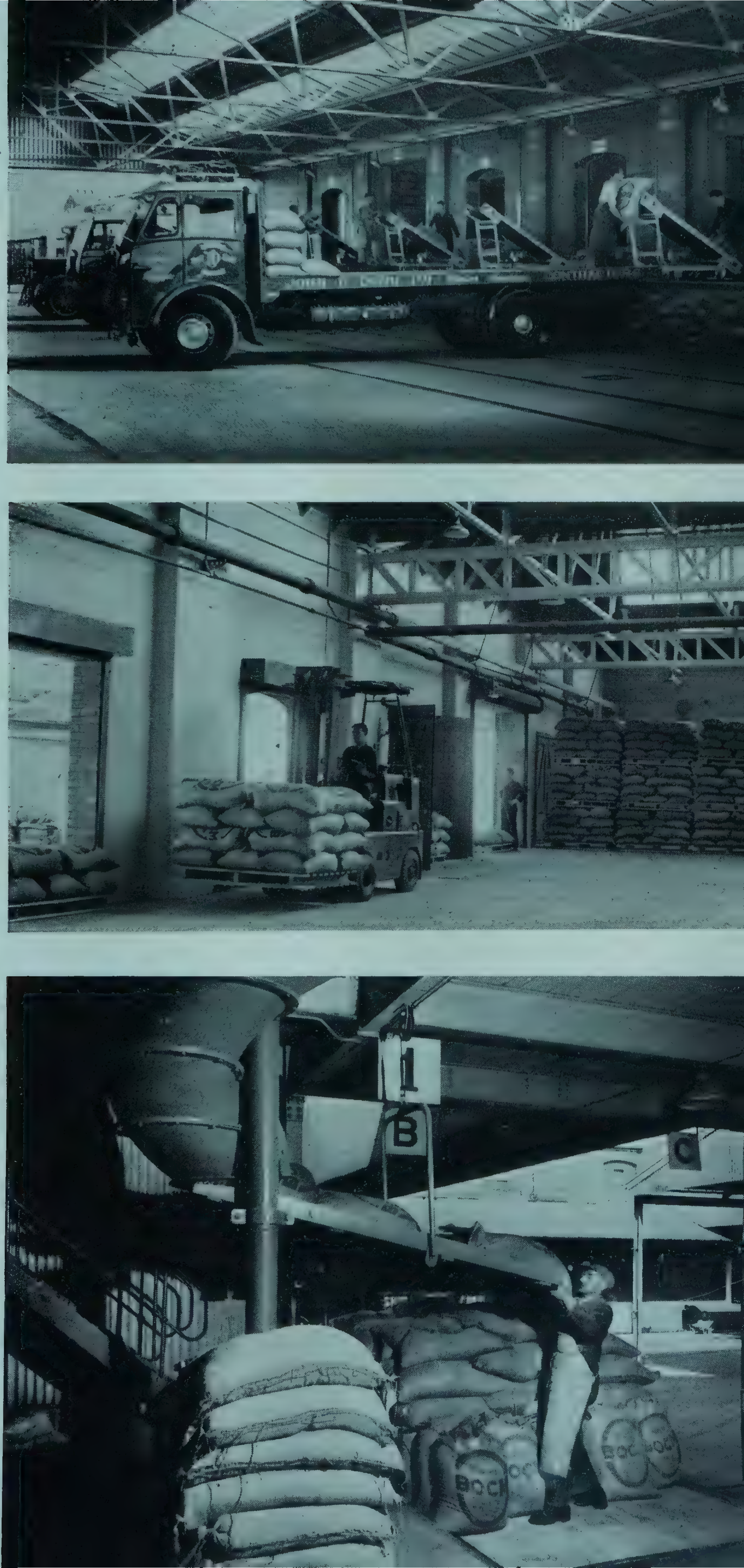
The delivery systems, just described, in large multi-floor or single storey warehouses may be automatically controlled by one man from a central position. The man sorts the bags of different products as they leave the central conveyor from the packers by push button control of a turn over valve or valves which delivers the bags into branch chutes feeding the various loading and storage bays. The bags containing each type of product may be printed in different colours, so that they may be sorted at a glance. The chutes may be fitted with electrically controlled spacers and counters which hold the bags in the chutes until released by the control man. In this way, the control man may regulate the number of bags and sort the number of products being sent from the packers. He also controls the quantities being released to the storage bays or loading points. The chutes can be kept full and, provided there is advance knowledge of the requirements of the load, the bags may be released immediately a wagon arrives at the mill. Automatic systems, although more expensive in initial outlay, employ a minimum of labour.

6. Stacking of Bags

The method to be adopted in the stacking of bags depends on the moisture content and temperature of the product, the construction and strength of the floor and the height available. Raw materials, with a low moisture content, may be laid flat longitudinally in tiers of up to 30 high or more on a strong concrete floor without the bottom bags becoming hard. Finished products, which normally contain more moisture, are often topped on end two or three high in bays of three or more rows. Space between each bay should be allowed for the circulation of air. In cases of high moisture contents and concrete floors, it is beneficial to place the bags on raised timber boards or pallets so that air can circulate underneath the stack as well.

7. Palletisation

This is a system of stacking and handling bags which employs fork lift trucks and pallets. The fork is inserted into the pallets, which are lifted up to a height of about 15 ft., according to the size of the truck, while the truck, which is driven by the operator, conveys them to any desired point.


1
B
BOC
BOC
BOC
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GS. 194A, B, C.—
oading bays of
rge mills.

(A)

(B)

(C)

The packers lay the bags flat on the pallets, which may conveniently carry a ton made up of 20 bags in four rows, or other quantities according to the size of pallet and truck. The forked lift truck picks up the pallet and conveys it to the stack or places it directly on to the lorry. If long distances have to be covered, the pallet is deposited by the truck on to a bogie which conveys it to the loading point or to the stack where another truck lifts it. When loading from a bogie from ground level, portable inclined band conveyors may be conveniently arranged to convey the bags on to the shoulders of the men standing on the lorries.

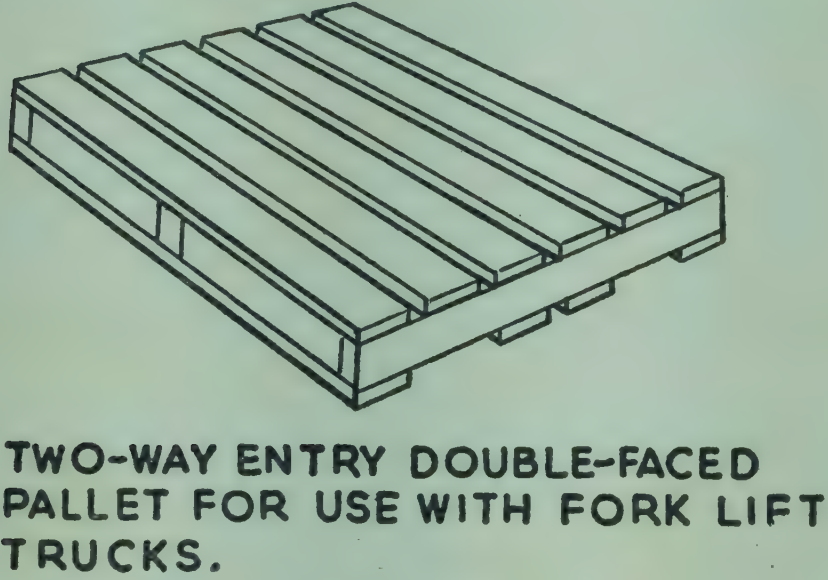
TWO-WAY ENTRY DOUBLE-FACED PALLET FOR USE WITH FORK LIFT TRUCKS.

FIG. 195.—Pallet.

The pallets are stacked one on top of the other, the number of pallets depending on the size of the pallet and truck, the moisture content of the product and the height available. An ideal stack is, however, usually three high. This is a convenient height for the insertion of the forks and there is little danger in the material in the bottom bags becoming hard.

Palletisation approximately halves labour cost and ensures the quick loading of transport as compared with hand-trucking methods, and it is particularly suitable for large single-storey warehouses. It makes stocktaking easy and, as has been mentioned, the method of stacking on pallets allows for the circulation of air, thereby keeping the products cool and preventing damage from vermin. In some applications of the system, assorted loads may be made up in advance on the pallets ready for the wagons when they arrive.

The cost of forked lift trucks and pallets is, however, high and capital outlay for this system is, therefore, only justified for large capacity warehouses. The renewal of batteries for the trucks is also an expensive item. For this reason, bogies should be used when conveying pallets more than a distance of approximately 100 ft., the trucks being reserved for lifting as much as possible.

8. The Delivery of Bags in Rotation

One of the objects of efficient storage systems is to ensure that each kind of finished product is delivered in proper rotation and that all products are stored for approximately the same period. This is particularly important in compound and provender milling because it is necessary to make due allowance for loss of weight through evaporation of moisture during storage. Some products may have to be packed overweight to ensure that by the time they leave the mill the weight is correct or even slightly overweight to allow for some evaporation loss in transit. Also, bags stored in one place for long periods are more subject to damage from rats and other vermin and their contents, if too moist, are liable to overheat and germinate.

9. The Recording of Bags on Delivery

When sack chutes are used for delivery purposes, check counters are invaluable as an additional check on the number of sacks leaving the warehouse. The simplest type consists of a single or a number of slats or rods connected on a hinge to a counter. As the bag passes, it lifts the slat or slats and automatically records its passage on the counter. Another type uses the principle of a ray of light on a photo-electric cell which is interrupted by the bags' passage. A drawback in each case is that two sacks coming down a chute may pass together and be recorded as one, but this may be overcome by the installation of a combined sack spacer and counter.

The most efficient combined sack spacer and counter incorporates an electrically driven rotor or spacer that passes the sacks one at a time from a chute on to a loading step. The sack is recorded by depressing a striker when passing over the rotor and, on reaching the loading step, it depresses another striker, which cuts out the motor, thereby preventing any more sacks from being delivered until the sack is removed by the carter. The spacer may be pre-set to pass the exact number of sacks required for the load. These devices save labour for handling, besides being an additional check on the number of sacks delivered from the mill.

Chapter XXIII

LAYOUT OF COMPOUND AND PROVENDER MILLS

THE problems involved in the planning and erection of a new mill or the reconstruction of an old one are of a complex nature. Compound milling has developed very rapidly over the last twenty years and millers are finding that, even if they have the necessary up to date technical knowledge, they have neither the time nor the facilities to cope with the work of a major mill reconstruction. The milling engineer, on the other hand, has experience of a wide variety of compound mills throughout the world—much wider, in fact, than any single compound miller can possibly have. The benefit of this experience is, therefore, invaluable to the development and planning of individual layouts and it is always advisable for the miller to consult the engineer.

Individual layouts of plant and buildings are affected by many factors. Much depends on conditions relating to the supply of raw materials and the distribution of finished products.

For example, in this country most of the larger mills are situated at the ports, because they rely largely on imports for their raw materials and distribute their finished products to wholesalers and merchants or their own centralised depots throughout the country. On the other hand, smaller mills or merchants are usually situated in inland agricultural areas because they distribute their products direct to farmers in their own localities; they buy the farmer's home-grown grain and return it to him in processed form, either as seed grain or as ground ' straights ', or they blend and mix the ground meals with other materials from the ports or elsewhere to make compounds. Whereas many smaller compound millers act largely as distributors or merchants, larger millers process many of their own raw materials; for example, some crush their own imported oilseeds, thus obtaining their own cakes; and others manufacture their own wheat by-products or offals in the flour milling process.

These types of compound mills necessarily vary widely in layout but, in deciding on a suitable building and site, there are a number of factors common to all to be considered. These include the suitability and cost of land, foundations, rates, freight charges, by-laws, the availability of essential services such as power, the accessibility of the mill to road, rail or water and other local conditions.

The suitability of the land is important because it determines the nature and, particularly, the height of the building, since the maximum load that can be put on the foundations will decide the relationship of building height to building area. This affects the layout, since a low and wide building with poor foundations will mean much horizontal conveying of the products and consequently additional power and cost of conveying equipment. Normally, therefore, the ideal is that the building should consist of a number of floors: in small mills, preferably four, as illustrated in Fig. 196, thereby making the best use of gravity and eliminating as many elevators and conveyors as possible.

The above considerations are, of course, governed by whether or not the plant is to be installed in a new or an existing building. In each case, however, the ideal to be aimed at is a low capital cost for building or conversion work combined with the most suitable layout for efficient and economical running.

As grain plays a smaller part in compound mills the silos or bins are usually incorporated in the mill building and separate silo constructions as in flour mills are seldom found. As has been explained in Chapter IV, large compound mills usually contain a few large bins for grain and sometimes cakes and a larger number of smaller process bins for meals. Small mills usually only contain bins for grain and cakes, the remaining materials being stored in the bags in which they are transported. As even in large mills, a large proportion of compound materials is stored in bags, a large warehouse is required for bagged raw materials. The warehouse should be arranged adjacent to the process bins preferably with conveyors below floor level running throughout its length. The bagged materials may then be conveniently tipped into the conveyors which convey them to a bucket elevator feeding the process bins. In smaller mills, having batch plants, the bagged materials should be stored in as accessible a position as possible to the mixers.

Whenever possible, high speed grinders should be installed in separate compartments adjacent to the main compound plant because better insurance rates are obtained. In general, heavier machines should be arranged on lower floors to reduce the loads and cheapen the construction of the building. This is, however, not done in the case of cubing machines except in single storey buildings because, as has been mentioned previously, the cooler should be situated immediately underneath the cubing machine to avoid cube breakage. Fans and cyclones should be as near to the top of the building as possible so that the cyclone can discharge to atmosphere through the roof.

Fig. 196 is a model of a batch mixing and cubing plant in which the layout of machines may be seen at a glance. The plant is described in Chapter XII.

Fig. 197 is a model of a semi-continuous mixing and cubing plant employing portable hand operated weighers also as described in Chapter XII. The grain and kibbled cake bins are also shown together with the high speed grinders which deliver the ground products pneumatically into the meal bins above the weighers.

The layout of a volumetric continuous plant is similar to the above except that the weighers and conveyor are replaced by feeders and mixing worms and the batch mixers in the weigher plant are dispensed with.

The frontispiece shows a model of a large compound and provender mill showing delivery to road and rail wagons and incorporates a 2 ton per hour maize flaking plant, a seed cleaning plant, a cut corn plant, a compound plant and a 1 ton per hour stone grinder plant, all as described throughout the book. It will be noted that this mill has eight floors, thus making the best use of gravity and reducing the number of elevators to a minimum. In this way, each plant is arranged in a line from top to bottom of the mill.

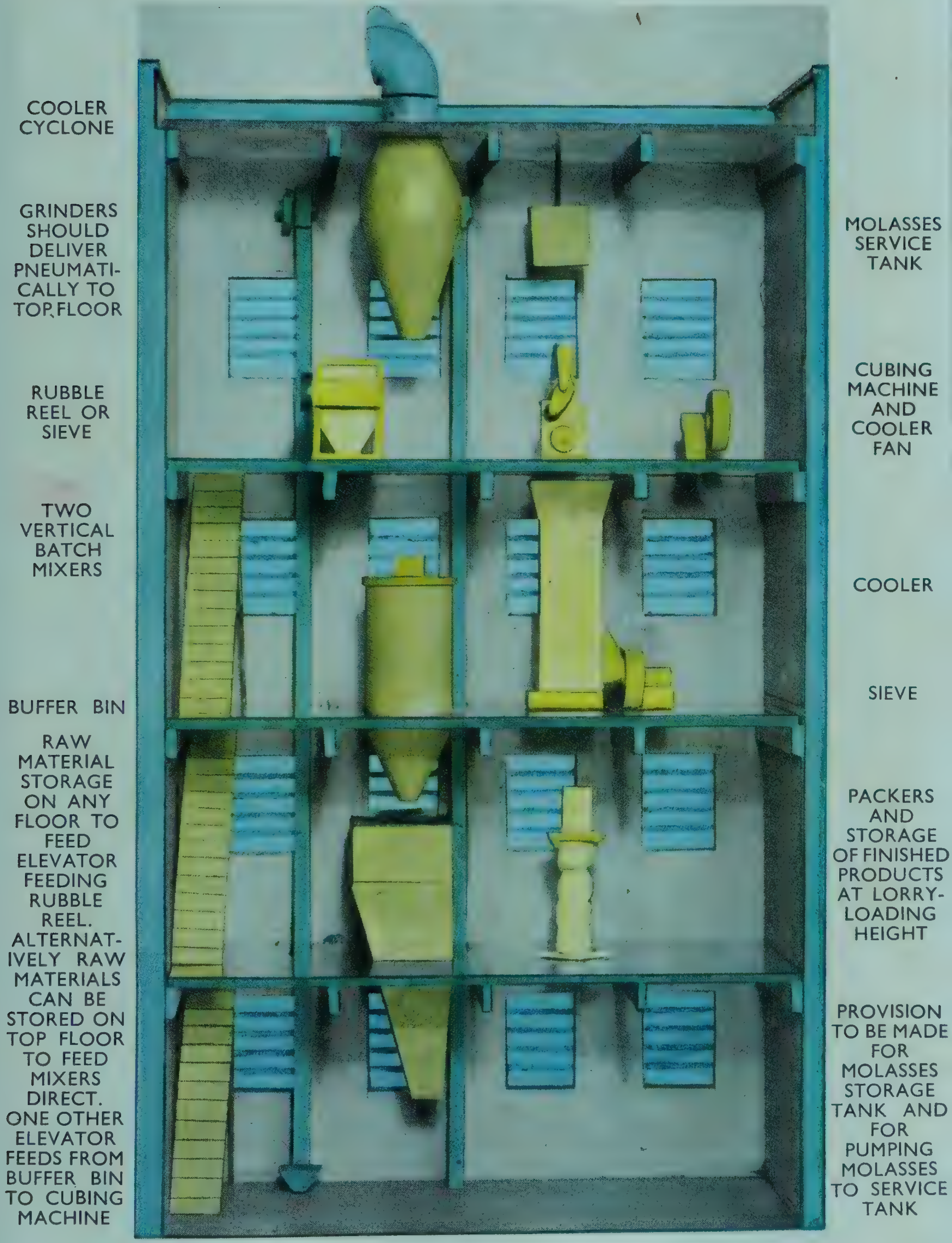
COOLER CYCLONE
GRINDERS SHOULD DELIVER PNEUMATICALLY TO TOP FLOOR
RUBBLE REEL OR SIEVE
TWO VERTICAL BATCH MIXERS
BUFFER BIN
RAW MATERIAL STORAGE ON ANY FLOOR TO FEED ELEVATOR FEEDING RUBBLE REEL. ALTERNATIVELY RAW MATERIALS CAN BE STORED ON TOP FLOOR TO FEED MIXERS DIRECT. ONE OTHER ELEVATOR FEEDS FROM BUFFER BIN TO CUBING MACHINE
MOLASSES SERVICE TANK
CUBING MACHINE AND COOLER FAN
COOLER
SIEVE
PACKERS AND STORAGE OF FINISHED PRODUCTS AT LORRY-LOADING HEIGHT
PROVISION TO BE MADE FOR MOLASSES STORAGE TANK AND FOR PUMPING MOLASSES TO SERVICE TANK

FIG. 196.—A Model of a Batch Mixing and Cubing plant (top floor 16 ft. high minimum, remainder 10 ft. minimum)

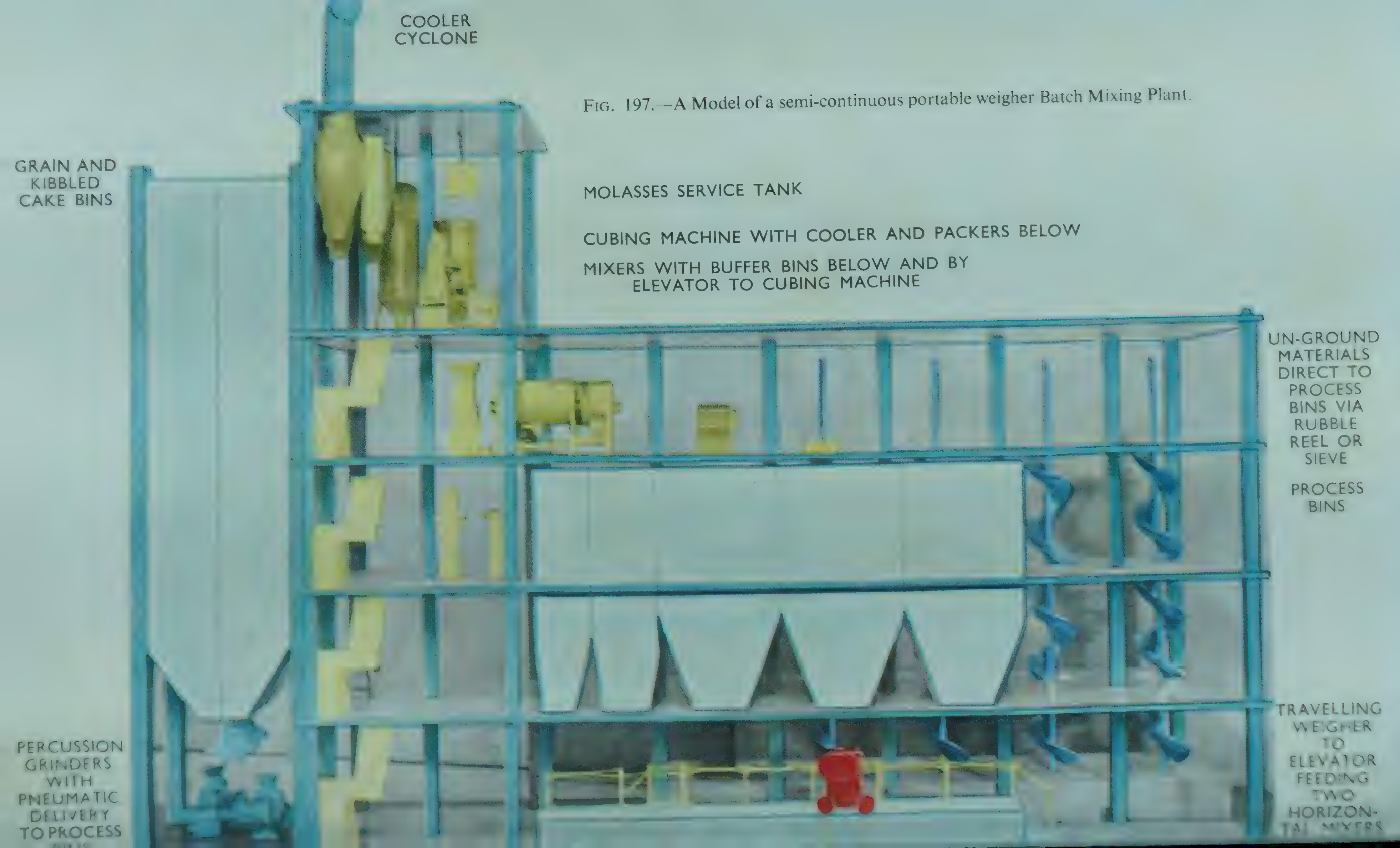
COOLER CYCLONE
GRAIN AND KIBBLED CAKE BINS
MOLASSES SERVICE TANK
CUBING MACHINE WITH COOLER AND PACKERS BELOW
MIXERS WITH BUFFER BINS BELOW AND BY ELEVATOR TO CUBING MACHINE
UN-GROUND MATERIALS DIRECT TO PROCESS BINS VIA RUBBLE REEL OR SIEVE
PROCESS BINS
PERCUSSION GRINDERS WITH PNEUMATIC DELIVERY TO PROCESS
TRAVELLING WEIGHER TO ELEVATOR FEEDING TWO HORIZONTAL MIXERS

FIG. 197.—A Model of a semi-continuous portable weigher Batch Mixing Plant.

Chapter XXIV

PRODUCTION COSTS

In view of present changing conditions and particularly owing to the wide variety of types of compound and provender mills, it is only possible to deal with the question of costs in a general way. It is hard to find two compound mills alike and much depends on the layout of buildings, the type of plant and local conditions. Therefore, detailed cost figures based on any particular mill are only apt to be misleading. Average figures of production costs are, however, given below as a rough guide.

In general, costs may be placed in the following categories :

(1) Interest, depreciation, insurance, rates, income tax, directors' fees, lighting, telephones, etc.
(2) Fuel and power.
(3) Maintenance to buildings, plant and transport.
(4) Supervision, office and transport salaries.
(5) Production wages including warehouse.
(6) Selling expenses including travellers, advertising, etc.
(7) Sacks and bags.

An indication of production costs, excluding all overheads, for a cubing and pelleting plant, including grinding, mixing and labour for handling the intake of raw materials and delivery of finished products may be worked out on the following lines :

(1) Wages for production men.
(2) Wages for intake and delivery men.
(3) Fuel for boiler.
(4) Power for plant.
(5) Maintenance charges.
Grinder beaters and screens, dies and rolls of cubing machines, etc.

In present times and assuming an average of a number of batch plants having an output of 10 tons per hour of compounds in cube and pellet form, the production cost would be expected in most conditions to be between 25s. and 30s. per ton if the above items were included.

In general, the main factor affecting production costs is labour and, assuming a plant of similar output to the above, roughly about 20-25 per cent less labour is required in an automatic continuous plant than in a batch plant. This amounts to about 2s. 6d. per ton for a 10 ton per hour plant and reduces the above cost to between 22s. 6d. and 27s. 6d. per ton. As already mentioned these figures are only intended as a very rough guide and they may be affected by the layout of buildings and the type of plant.

As labour mainly affects production costs, the following is an indication of the men required and the cost of labour for various types of plant in average conditions. It is assumed that each plant is working an 8 hour day for 5 days per week.

2 tons per Batch Cubing and Pelleting Plant

	Men
Intake and loading out (including general jobs, sack cleaning and mending, etc.)	4
Grinders (packing and supervision)	1
Mixing and packing	2
Charge hand or foreman (supervising cubing plant, etc.)	1
	8

Assuming an average wage of £7 per week per man, the total labour cost per week is £56 for 80 tons which equals 14s. per ton.

5 tons per Batch Cubing and Pelleting Plant

	Men
Intake and loading out	6
Grinders	3
Mixers	2
Packers	4
Maintenance	1
Charge hand or foreman	1
	17

Assuming an average wage of £7 per week per man the total labour cost per week is £119 for 200 tons which equals 11s. 11d. per ton.

10 *tons per hour Batch Cubing and Pelleting Plant*

	Men
Intake and loading out	10
Grinders, 1 man supervising, 3 men packing	4
Mixers	6
Packers (assuming automatic stitchers)	6
Maintenance	1
Charge hand or foreman	1
	28

Assuming an average wage of £7 per week per man the total labour cost per week is £182 for 400 tons which equals 9s. 9½d. per ton.

10 *tons per hour Continuous Cubing and Pelleting Plant*

	Men
Intake and loading out	10
Grinders (supervision only)	1
Filling bins	1
Supervising feeders	1
Packers (assuming automatic stitchers)	6
Maintenance	1
Charge hand or foreman	1
	21

Assuming an average wage of £7 per week per man the total labour cost per week is £147 for 400 tons which equals 7s. 4½d. per ton.

It will be noted that as the output increases the cost per ton is considerably reduced. Also, as previously estimated, the cost per ton of the 10 tons per hour continuous plant works out at 2s. 5d. per ton less than the batch plant of similar output. It must again be stressed, however, that in view of varying conditions these figures should be accepted with reserve.

GRINDING COSTS

Prior to the last war when Millstones and Vertical Emery Grinders were in more extensive use, it was generally understood that the cost of replacing and furrowing stones averaged 4d. per ton of barley meal produced and, although power was relatively cheaper and wages lower, the small output obtained on Millstones and Emery Grinders brought up the all-in cost of finished products to a substantial figure.

In the case of large capacity modern high speed grinders, the average replacement cost for beaters is now 3d. per ton, plus an additional 1d. per ton for screen wear. When grinding oats, barley, etc., it has been established that the main cause of excessive beater wear is the silica content in the material being ground, and dry screening in these cases prior to grinding is particularly advisable.

Labour charges are also the main factor affecting grinding costs and they vary to a considerable degree according to the amount of automatic operation of the plant in question.

BOILER COSTS

To select a suitable type of boiler for any particular plant, it is necessary to consider the initial cost in relation to the operating cost and the rate of depreciation over a period of years. There are a number of varying factors which have to be considered such as labour, the costs of fuel in different areas, tariffs, which are lower if the plant runs 24 hours a day instead of 8 hours, separate housings, cleanliness and storage space for fuel. It is impracticable to give accurate figures to provide for all these contingencies, but the following may be taken as a rough guide at the time of going to press, and indications are given where variations occur.

FUEL COSTS OF VARIOUS TYPES OF BOILERS SUITABLE FOR A SMALL CUBING PLANT

In each case the figures given below refer to the fuel cost of raising 300 lb. of steam per hour.

Type of boiler	*Fuel*	*Cost*	*Remarks*
Coal fired	——	3/-	Excluding labour costs.
Oil fired	Oil at 1/2 per gallon	3/6	
Gas fired	4/- per 1000 cu. ft. at calorific value of approximately 500 B.T.U.s.	4/-	Subject to variation of cost of gas.
Electric	100 units at 280/320 lb. of steam at average rate of ¾d. per unit.	6/3	Subject to variation of cost of electricity.

The coal or peat hand fired boiler is still used, particularly where coal is immediately available, because it is cheaper than other types both as regards initial cost and fuel consumption. On the other hand, owing to the constant supervision and labour that it requires, it is doubtful whether the total operating costs are less than the automatic oil or gas fired type of boiler.

The main disadvantages of coal fired boilers are the problems of storing the fuel, which occupies much space, and the constant dirty atmosphere which usually necessitates the boiler house being situated some distance from the plant. The annual rates of depreciation will, of course, be less on cheaper types of boiler.

The oil fired boiler is popular for use in cubing plants because the fully automatic type of burner will operate for long periods with only occasional adjustment, and the inclusion of alarm systems takes care of interruptions in the steam supply. For an output of 300 lb. of steam per hour, the fully automatic oil fired boiler is initially nearly double the cost of the foregoing, but oil is the next cheapest fuel to coal and labour costs are negligible. Unfortunately, however, the question of fuel storage and polluted atmosphere has again to be considered.

For the latter reason, the gas fired boiler has claims to be the most ideal form of steam producer, particularly for cubing plants which require low pressure steam. Although gas is usually more expensive than both the foregoing types of fuel, the initial cost of the boiler is little more than the coal fired type, and the clean conditions, the simplicity of operation and the saving of fuel storage space more than compensate for the dearer fuel.

Owing to the cost of electricity, the operating costs of electric boilers are considerably higher than other types. Modern electric boilers can, however, be accommodated in the vicinity of the plant so that a separate housing can be ignored. In some conditions this is a considerable saving when assessing total costs over a long period.

Electric boilers also give an air of cleanliness and efficiency to any modern plant, and some types are cheaper than the fully automatic oil fired type. Fully automatic alarm systems are also incorporated on electric boilers and, in the immersed electrode type, running costs are kept to the lowest possible in relation to the cost of electricity.

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CAPACITIES, SPEEDS AND POWER CONSUMPTIONS OF MACHINES

Machine	*Size*	*Capacity*	*H.P.*	*R.P.M.*	*Remarks*
Intake Machinery					
Apex Rubble Separator . .	18 in.	12 ton/hour	1½	30-40	On maize (Plate) and barley.
		10 ,,			On oats.
		15 ,,			On wheat.
	24 ,,	20 ,,	1½	30-40	On maize (Plate) and barley.
		15 ,,			On oats.
		25 ,,			On wheat.
	30 ,,	25 ,,	2	30-40	On maize (Plate) and barley.
		20 ,,			On oats.
		35 ,,			On wheat.
	36 ,,	30 ,,	2	30-40	On maize (Plate) and barley.
		25 ,,			On oats.
		45 ,,			On wheat.
	42 ,,	35 ,,	2½	30-40	On maize (Plate) and barley.
		30 ,,			On oats.
		60 ,,			On wheat.
	48 ,,	50 ,,	2½	30-40	On maize (Plate) and barley.
		35 ,,			On oats.
		75 ,,			On wheat.
	54 ,,	60 ,,	3	30-40	On maize (Plate) and barley.
		40 ,,			On oats.
		100 ,,			On wheat.
	60 ,,	90 ,,	3	30-40	On maize (Plate) and barley.
		80 ,,			On barley.
		45 ,,			On oats.
		120 ,,			On wheat.
Scalperator	24 in.	1000 bushels/hour	2	540	On wheat.
	36 ,,	1250 ,,	2¼	540	Maize, barley and oats, approximately in above relationship.
	48 ,,	2000 ,,	2½	515	
	60 ,,	2250 ,,	3¼	565	
	68 ,,	2500 ,,	4	580	
	76 ,,	3000 ,,	5	600	

Machine	*Size*	*Capacity*	*H.P.*	*R.P.M.*		*Remarks*
				Sieve	*Fan*	
Intake Machinery (contd.)						
Warehouse Separator (Simons)	18 in.	400 bushels/hour	3	380	570	On wheat.
	24 ,,	1000 ,,	4	380	570	Maize, barley and oats, approximately in above relationship.
	36 ,,	2000 ,,	5	388	570	
Ravelling Reel	3 shts.	20 ton/hour	1½	36		Speed of barrel.
Nicholson Cake Breaker	CBN	8-35 cwt./hour	1-3	100		On oilcake
	CBA	25-30 ,,	2	100		30 × 12 × ¾ in. slabs.
	CBD	40-45 ,,	3-4	180		,, ,, ,,
	8 NW	25-30 ,,	2	130		,, ,, ,,
	5 NW	10 ,,	1	100		,, ,, ,,
	7 NW	24-40 ,,	4	100		,, ,, ,,
	9 W	40-60 ,,	6	80-100		,, ,, ,,
Flextooth Crusher	24 × 20	10-15 ton/hour	25	750		On 30 × 12 × ¾ in. slabs.
	36 × 24	30 ,,	50	900		On 12 × 6 × 6 in. Burma groundnut or 19 in. diam. × 3 in. thick Sunflower cake.
Barron Cake Breaker		Up to 20 ton/hour	20			On 30 × 12 × ¾ in. slabs.
Molasses Intake						
Tankers, Pumps, Capacities, Pressures, etc., see page 66.						
Seed Cleaning Machinery						
Millerator	No. 20	100 bushels/hour	1	200		On wheat.
	No. 30	200 ,,	1½	975		Capacities depend on the amount of impurities and the degree of cleanliness required.
	No. 40	300 ,,	2	975		
Boby Cleaner	No. 1	30-40 bushels/hour	2	370		On wheat.
	No. 2	40-60 ,,	3	370		
	No. 3	60-80 ,,	5	370		

Machine	*Size*	*Capacity*	*H.P.*	*R.P.M.*		*Remarks*
Seed Cleaning Machinery (contd.)						
Duo Aspirator (Simon) . .	No. 24	200 bushels/hour	¾	490		On wheat.
	No. 36	300 ,,	1¼	570		
	No. 48	450 ,,	1¾	570		
Cyclo-Pneumatic Separator (Robinson) . . .	No. 3	5 ton/hour	¾	500		Cleaning capacity on grain, 40-60 bushels/hour.
	No. 2	10 ,,	1	500		140-200 bushels-ton.
	No. 1	20 ,,	1¼	500		200-300 ,,
	No. 0	35 ,,	1½	500		300-500 ,,
				Pulley	*Cylinder*	
Robinson Ultra Indented Cylinder	No. 3	5 qrs./hour	1·1	80	40	On grain, combined type LBM comprising two primary cylinders only.
	No. 5	10 ,,	2·25	105	35-40	
	No. 6	15 ,,	2·75	105	35-40	
	No. 7	20 ,,	3·5	90	30-40	,, ,, ,,
	No. 8	25 ,,	4·5	105-120	35-40	,, ,, ,,
Simon Disc Separator	1515	45 bushels/hour	½	60		Oats and barley from medium wheat.
		30 ,,	½	60		Cockle and small seeds ,,
	1522	70 ,,	½	60		Oats and barley ,,
		55 ,,	½	60		Cockle and small seeds ,,
	1823	85 ,,	1	60		Oats and barley ,,
		75 ,,	1	60		Cockle and small seeds ,,
	1827	110 ,,	1½	60		Oats and Barley ,,
		90 ,,	1½	60		Cockle and small seeds ,,
	2517	150 ,,	1½	190		Oats and barley ,,
		120 ,,	1½	160		Cockle and small seeds ,,
	2523	240 ,,	2	190		Oats and barley ,,
		190 ,,	2	160		Cockle and small seeds ,,
	2527	300 ,,	2½	190		Oats and barley ,,
		230 ,,	2½	160		Cockle and small seeds ,,

Machine	*Size*	*Capacity*	*H.P.*	*R.P.M.*	*Remarks*
Seed Cleaning Machinery (contd.)					
'Nalder' Oats and Barley Grader	No. 1	50 bushels/hour	½	45	Capacities are based on bushel weight of 38 lb. for oats, 47 lb. for barley and 60 lb. for wheat.
	No. 2	60 ,,	½	45	
	No. 3	75 ,,	½	45	
	No. 4	100 ,,	¾	40	,, ,, ,,
	No. 5	130 ,,	¾	40	,, ,, ,,
	No. 6	160 ,,	1	38	,, ,, ,,
	No. 7	220 ,,	1	35	,, ,, ,,
	No. 8	250 ,,	1	35	,, ,, ,,
Kaybee '50' Self contained cleaning machine (T. R. Walker)		1½ ton/hour	10	950	On seed grain.
Sieves and Reels					
Oscillating Sieve (Simon) .	48 Single		¼	500	Capacities of sieves and reels depend on nature of material and size of screen mesh.
	48 Double				
	72 Single		¼	500	
	72 Double				
Locker Rotex . . .	17 Sizes (1-5 decks)		1-5	215-300	Combined rotary and reciprocating sieves.
				Pulley *Barrel*	
Reel (Simon)	No. 30 2½ shts.		1½	70 36	
	No. 30 3 shts.		1½	70 36	
Centrifugal	No. 30 2½ shts.		1½	200	
	No. 30 3 shts.		1½	200	Single or double feed.
Feeders					
Mechanical Feeder . .		2-50 lb./hour	½	400	On meals.
Simon Measurer . . .		270 bushels/hour	½	5-35	Maximum capacity at 35 r.p.m. on wheat.

Machine	*Size*	*Capacity*		*H.P.*	*R.P.M.*	*Remarks*
Feeders (contd.)						
Volumetric Measurer (Simon)		250-7000 lb./hour		1	40	On meal at 28 lb. cu. feet.
Smith Mixer	No. 1	800 lb./hour maximum		¼	10-50	On meal.
	No. 2	1200 ,, ,,		¼	10-50	,,
	No. 3	3200 ,, ,,		¼	10-50	,,
	No. 4	5000 ,, ,,		¼	10-50	,,
	No. 5	7600 ,, ,,		½	10-50	,,
	No. 6	9600 ,, ,,		½	10-50	,,
	No. 7	12000 ,, ,,		½	10-50	,,
	No. 8	14000 ,, ,,		½	10-50	,,
	No. 9	18000 ,, ,,		½	10-50	,,
Shoe Feeder		12000 lb./hour Maximum		⅛	50	,,
Velofeeder (Simon) . .	12 in.	30 lb.-4 tons		¼		On bran.
		50 lb.-9 tons				On compound meal at 28 lb. cu. feet.
		60 lb.-10 tons				On kibbled cake.
	18 in.	30 lb.-5 tons		¼		On bran.
		50 lb.-11 tons				On compound meal.
		60 lb.-12 tons				On kibbled cake.
	24 in.	30 lb.-5½ tons		¼		On compound meal at 28 lb. cu. feet.
		50 lb.-12 tons		¼		On kibbled cake.
		60 lb.-13 tons				On bran.
Magnets						
		Grain	*Meal*			
Barron Electro-Magnet . .	6 in.	2 ton/hour	1 ton/hour			Capacity figures are approximate and depend on density and thickness of layer and speed of flow.
	9 ,,	3 ,,	1½ ,,			
	12 ,,	4½ ,,	2½ ,,			
	18 ,,	6 ,,	3 ,,			
	24 ,,	9 ,,	4½-5 ,,			

Machine	*Size*	*Capacity*	*H.P.*	*R.P.M.*	*Remarks*
Conditioning and Drying Machines					
Loring Centricity Humidifier .		Up to 8 ton/hour	2	2000	On meals.
Water Wheel Damper . .	No. 24	200 bushels/hour			
	No. 36	800 „			
Type F Dryer (Simon) . .		1-5 ton/hour	¼	80	On 6 per cent moisture extraction.
Grinders					
Dreadnought (Barron) . .	12 in.	¾ cwt./hour	2-3	750	On wheat.
		2 „	2-3	750	On barley.
	14 „	1 „	3-4	750	On wheat.
		2½ „	3-4	750	On barley.
	18 „	1½ „	4-6	650	On wheat.
		3½ „	4-6	650	On barley.
	20 „	2 „	6-8	650	On wheat.
		4 „	6-8	650	On barley.
	24 „	3 „	9-12	600	On wheat.
		5 „	9-12	600	On barley.
		4 „	9-12	600	On maize.
		2 „	9-12	600	On oats (Sussex Ground).
	30 „	5 „	12-16	550	On wheat.
		7 „	12-16	550	On barley.
		6 „	12-16	550	On maize.
		3 „	12-16	550	On oats (Sussex Ground).
	36 „	7½ „	16-20	500	On wheat.
		10 „	16-20	500	On barley.
		8 „	16-20	500	On maize.
		4-5 „	16-20	500	On oats (Sussex Ground).
Dreadnought (D.P. Type) .	24 in.	10-30 cwt./hour	12-15	700	Capacity varies according to material and fineness required.
	30 „	15-40 „	15-18	600	
	36 „	20-60 „	18-20	500	

Machine	Size	Capacity		H.P.	R.P.M.	Remarks
Grinders (contd.)						
Juggernaut (Turner)	No. 1 (36 in.)	8 cwt./hour		15-20	400-450	On wheat.
		10 „		15-20	400-450	On barley.
		8 „		15-20	400-450	On maize.
		4 „		15-20	400-450	On oats (Sussex Ground).
	No. 2 (30 in.)	6 „		11-15	450-500	On wheat.
		8 „		11-15	450-500	On barley.
		6 „		11-15	450-500	On maize.
		3 „		11-15	450-500	On oats (Sussex Ground).
Macrof (Turner) . . .	15 in.	4⅓ cwt./hour		15	2500	On maize through No. 30 wire.
	21 „	6-9 „		22-30	2200	„ „ „
	24 „	13-20 „		40-55	1900	„ „ „
Briton (Christy and Norris) .	LB.4	1/16 (1½ mm.) screen	⅛ (3 mm.) screen	10	5000	
		2-3 cwt./hour	4-6 cwt./hour	10		On oats (Sussex Ground).
		3-5 „	6-10 „	10		On wheat.
		3-4 „	6-8 „	10		On barley.
		6-8 „	12-15 „	10		On maize.
		9-10 „	18-20 „	10		On cake (Linseed).
		4-6 „	8-12 „	10		On cake (Cotton).
		10-12 „	20-20 „	10		On cake (Ground-nut).
	LB.7/2	3-5 „	6-10 „	15	5000	On oats (Sussex Ground).
		6-9 „	12-16 „	15		On wheat.
		5-7 „	10-14 „	15		On barley.
		10-13 „	20-25 „	15		On maize.
		14-16 „	28-31 „	15		On cake (Linseed).
		6-9 „	12-18 „	15		On cake (Cotton).
		15-18 „	30-36 „	15		On cake (Ground-nut).
	B 7/2	9-13 „	18-26 „	35	3000	On oats (Sussex Ground).
		15-19 „	30-38 „	35		On wheat.
		12-16 „	24-32 „	35		On barley.
		29-34 „	58-68 „	35		On maize.
		33-37 „	66-74 „	35		On cake (Linseed).

Machine	*Size*	*Capacity*			*H.P.*	*R.P.M.*	*Remarks*
Grinders (contd.)							
Briton (Christy and Norris)	B 7/2	14-21 cwt./hour	28-42 cwt./hour		35		On cake (Cotton).
		35-43 ,,	70-86 ,,		35		On cake (Ground-nut).
	B 11/2	15-20 ,,	30-40 ,,		55	3000	On oats (Sussex Ground).
		25-31 ,,	50-62 ,,		55		On wheat.
		20-25 ,,	40-50 ,,		55		On barley.
		44-51 ,,	88-100 ,,		55		On maize.
		50-58 ,,	100-110 ,,		55		On cake (Linseed).
		22-33 ,,	44-66 ,,		55		On cake (Cotton).
		55-66 ,,	110-130 ,,		55		On cake (Ground-nut).
	B 14/2	21-27 ,,	42-54 ,,		75	3000	On oats (Sussex Ground).
		34-43 ,,	68-86 ,,		75		On wheat.
		27-32 ,,	54-64 ,,		75		On barley.
		61-70 ,,	120-140 ,,		75		On maize.
		69-80 ,,	135-160 ,,		75		On cake (Linseed).
		32-45 ,,	64-90 ,,		75		On cake (Cotton).
		75-91 ,,	150-180 ,,		75		On cake (Ground-nut).
	B 21/2	30-40 ,,	60-80 ,,		110	3000	On oats (Sussex Ground).
		50-60 ,,	100-200 ,,		110		On wheat.
		40-50 ,,	80-100 ,,		110		On barley.
		88-100 ,,	170-200 ,,		110		On maize.
		100-116 ,,	200-220 ,,		110		On cake (Linseed).
		44-66 ,,	88-130 ,,		110		On cake (Cotton).
		110-130 ,,	220-260 ,,		110		On cake (Ground-nut).
		$\frac{3}{32}$ in. screen	$\frac{1}{16}$ in. screen	$\frac{1}{8}$ in. screen			
Barron Impact . . .	No. 0	10 cwt./hour	6 cwt./hour	15 cwt./hour	6	4000	On maize.
		4 ,,	2 ,,	7-8 ,,			On barley.
		4 ,,	2 ,,	5-6 ,,			On oats.
	No. 1	15-16 ,,	10-12 ,,	20-24 ,,	12	4000	On maize.
		8-9 ,,	4 ,,	16-18 ,,			On barley.
		6 ,,	4 ,,	8-10 ,,			On oats.

Machine	*Size*	*Capacity*			*H.P.*	*R.P.M.*	*Remarks*
Grinders (contd.)							
Barron Impact	No. 2	30 cwt./hour	20-25 cwt./hour	40-45 cwt./hour	25	3300	On maize.
		19 "	10 "	28 "			On barley.
		12 "	7-8 "	14-16 "			On oats.
	No. 3	45 "	30-35 "	60 "	35	3000	On maize.
		28 "	16 "	40 "			On barley.
		15-16 "	10 "	22-25 "			On oats.
	No. 4	75 "	60-65 "	90-100 "	60	3000	On maize.
		40 "	25 "	55-57 "			On barley.
		30 "	20 "	40-45 "			On oats.
Premier (Porteus) . . .	No. 2		1·69 mm. screen	2·25 mm. screen	20	4600	
			4½-5 cwt./hour	5-6 cwt./hour	20		On oats (English).
			5-6 "	7-8 "	20		On oats (Canadian).
			12-14 "		20		On wheat.
			7-8 "	9-11 "	20		On barley (English).
			9-11 "	11-12 "	20		On barley (Russian).
			12-14 "	15-17 "	20		On maize (Plate).
	No. 3		8-9 "	10-11 "	35	4600	On oats (English).
			10-11 "	12-13 "	35		On oats (Canadian).
			27 "		35		On wheat.
			15 "	17 "	35		On barley (English).
			17 "	21 "	35		On barley (Russian).
			27 "	34 "	35		On maize (Plate).
	No. 4		20 "	25 "	65	4600	On oats (English).
			23 "	28 "	65		On oats (Canadian).
			45-47 "		65		On wheat.
			30 "	36 "	65		On barley (English).
			34 "	42 "	65		On barley (Russian).
			46-47 "	56-58 "	65		On maize (Plate).

Machine	*Size*	*Capacity*	*H.P.*	*H.P.*	*R.P.M.*	*Remarks*
Mixers						
Barron Fountain Mixer . .	5 cwt.	1 ton/hour	25	1	120-180	Capacities of batch mixers given are maximum and depend on rate of feeding.
	10 ,,	2 ,,		2	120-180	
	20 ,,	4 ,,		3	120-180	
	30 ,,	6 ,,		6	120-180	
	40 ,,	8 ,,		8	120-180	
Barron Horizontal Mixer .	5 ,,	1 ,,		5	160	
	10 ,,	2 ,,		7½	112	
	15 ,,	4 ,,		10	140	
	20 ,,	6 ,,		15	140	
	40 ,,	8 ,,		30	145	
Cascade Continuous Mixer (Simon)		4/5 ton/hour		3	180	
Duplex Continuous Mixer . (Howes)		25 ,,		15-20	150-250	On molasses meals.
		20 ,,		5-10	200-300	On dry meals.
Tattersall Cold Molasses Mixer	No. 1	3 ton/hour		Mixer 13	1100	Power figures given are used when mixing 10 per cent Molasses.
				Pump 2	825	
	No. 0	5-6 ,,		Mixer 22	900	
				Pump 3	825	
Cubing and Pelleting Machines.	See page 170.					
Coolers						
Simon Double Column Cooler	2A	2-3 ton/hour		½	1·53	On cubes and pellets, figures given are powers and speeds of discharge gates.
	2A2	5-6 ,,		½	3·20	
	2A3	6-8 ,,		⅝	6·4	
	2A4	10 ,,		⅝	6·4	
Flaking Machines						
Vertical Cookers (Turner) .		10 cwt./hour			120	On maize.
Flaking Roll (Simon) . .	36 × 18	10 cwt./hour		25	150	On maize

Machine	*Size*	*Capacity*	*H.P.*	*H.P.*	*R.P.M.*	*Remarks*
Flaking Machines (contd.)				*Open Drive*	*Bevel Drive*	Power depends on roll setting.
Cascade Flake Dryer (Turner) .	24/36, 4 sections	5 cwt./hour	25	75	150	On maize, steam consumption 225 lb./hr.
	24/36, 5 sections	10 ,,		75	150	,, ,, ,, 355 ,,
	24/54, 5 sections 36/54, 4 sections	20 ,,		75	150	,, ,, ,, 650 ,,
	36/54, 5 sections	30 ,,		75	150	,, ,, ,, 865 ,,
	36/54, 5 sections	40 ,,		75	150	,, ,, ,, 920 ,,
	36/54, 6 sections	50 ,,		75	150	,, ,, ,, 1200 ,,
	36/54, 6 sections	60 ,,		75	150	,, ,, ,, 1400 ,,
Corn Cutting, Clipping and Polishing, Crushing, etc.						
Barron Corn Cutter . .	No. 1	14 cwt./hour		3-5	750	On maize.
		5 ,,				On wheat.
	No. 2	1 ton/hour		8-10	625	On maize.
		9 cwt./hour				On wheat.
	No. 3	2 ton/hour		12-15	570	On maize.
		15 cwt./hour				On wheat.
Howes Corn Cutter . .	Junior	11½-13½ cwt./hour		2½-3	700	On maize.
	No. 0	21½-26½ ,,		4-5	600	,,
	No. 1	35-42 ,,		5½-7	600	,,
	No. 2	42-70 ,,		8-14	550	,,
Barron Oat Clipper . .		4½ cwt./hour		4-5	750	
		Clipping	*Polishing*			
Porteus Oat Clipper and Polisher	1A	40-50 bushels/hour	45-55 bushels/hour	4-6	550	
	2A	55-65 bushels/hour	65-75 bushels/hour	6-8	525	
	3A	100-120 bushels/hour	110-130 bushels/hour	8-10	500	
	4A	130-150 bushels/hour	140-160 bushels/hour	10-12	450	
Barron Oat Crushing Roll .		15-20 cwt./hour		5	250	

Note: The information given above is supplied by the manufacturers of the machines in question.

USEFUL TABLES

CONVERSION TABLE—INCHES TO MILLIMETRES

Inches	0	1	2	3	4	5	6	7	8	9	10	11
0	—	25·40	50·79	76·19	101·60	127·00	152·40	177·79	203·19	228·60	254·00	279·39
$\frac{1}{16}$	1·587	26·99	52·38	77·78	103·18	128·58	153·98	179·38	204·78	230·18	255·58	280·98
$\frac{1}{8}$	3·175	28·57	53·97	79.37	104·77	130·17	155·57	180·97	206·37	231·77	257·17	282·57
$\frac{3}{16}$	4·672	30·16	55·56	80·96	106·36	131·76	157·16	182·56	207·96	233·36	258·76	284·16
$\frac{1}{4}$	6·349	31·75	57·15	82·55	107·95	133·35	158·75	184·15	209·55	234·94	260·34	285·74
$\frac{5}{16}$	7·937	33·34	58·73	84·13	109·53	134·93	160·33	185·73	211·13	236·53	261·93	287·33
$\frac{3}{8}$	9·524	34·92	60·32	85·72	111·12	136·52	161·92	187·32	212·72	238·12	263·52	288·92
$\frac{7}{16}$	11·112	36·51	61·91	87·31	112·71	138·11	163·51	188·91	214·31	239·71	265·11	290·51
$\frac{1}{2}$	12·699	38·10	63·50	88·90	114·29	139·70	165·10	190·50	215·89	241·29	266·69	292·09
$\frac{9}{16}$	14·287	39·38	65·08	90·48	115·88	141·28	166·68	192·08	217·48	242·88	268·28	293·68
$\frac{5}{8}$	15·871	41·27	66·67	92·07	117·47	142·87	168·27	193·67	219·07	244·47	269·87	295·27
$\frac{11}{16}$	17·462	42·86	68·26	93·66	119·06	144·46	169·86	195·26	220·66	246·06	271·46	296·86
$\frac{3}{4}$	19·049	44·45	69·85	95·25	120·65	146·05	171·45	196·84	222·24	247·64	273·04	298·44
$\frac{13}{16}$	20·637	46·01	71·44	96·83	122·23	147·63	173·03	198·43	223·88	249·23	274·63	300·03
$\frac{7}{8}$	22·224	47·62	73·02	98·42	123·82	149·22	174·62	200·02	225·42	250·82	276·22	301·62
$\frac{15}{16}$	23·812	49·21	74·61	100·01	125·41	150·81	176·21	201·61	227·01	252·40	277·80	303·20

FRACTIONS OF INCHES TO MILLIMETRES

$\frac{1}{32}$ In.	Mm.	$\frac{1}{32}$ In.	Mm.	$\frac{1}{64}$ In.	Mm.	$\frac{1}{64}$ In.	Mm.	$\frac{1}{64}$ In.	Mm.	$\frac{1}{64}$ In.	Mm.
1	0·7937	17	13·4937	1	0·3969	17	6·7469	33	13·0969	49	19·4407
3	2·3812	19	15·0812	3	1·1906	19	7·5406	35	13·8906	51	20·2406
5	3·9687	21	16·6687	5	1·9844	21	8·3344	37	14·6844	53	21·0344
7	5·5562	23	18·2562	7	2·7781	23	9·1281	39	15·4781	55	21·8281
9	7·1437	25	19·8437	9	3·5719	25	9·9219	41	16·2719	57	22·6219
11	8·7312	27	21·4312	11	4·3656	27	10·7156	43	17·0656	59	23·4156
13	10·3187	29	23·0187	13	5·1594	29	11·5094	45	17·8594	61	24·2094
15	11·9062	31	24·6062	15	5·9531	31	12·3031	47	18·6531	63	25·0031

USEFUL TABLES

HORSE-POWER OF BELTING

Per Inch of Width

Velocity of Belt in Feet per Minute	Best Oak-tanned Leather Belts			Balata Belts					
	Single Belts	Light Double Belts	Heavy Double Belts	3 ply	4 ply	5 ply	6 ply	7 ply	8 ply
100	0·15	0·21	0·27	0·12	0·18	0·24	0·30	0·36	0·42
200	0·30	0·42	0·55	0·24	0·36	0·48	0·61	0·73	0·85
300	0·45	0·64	0·82	0·36	0·54	0·73	0·91	1·09	1·27
400	0·61	0·85	1·09	0·48	0·73	0·97	1·21	1·45	1·70
500	0·76	1·06	1·36	0·61	0·91	1·21	1·51	1·82	2·12
600	0·91	1·27	1·64	0·73	1·09	1·45	1·82	2·18	2·54
700	1·06	1·49	1·91	0·85	1·27	1·70	2·12	2·54	2·97
800	1·21	1·70	2·18	0·97	1·45	1·94	2·42	2·91	3·39
900	1·36	1·91	2·45	1·09	1·64	2·18	2·73	3·27	3·82
1000	1·51	2·12	2·73	1·21	1·82	2·42	3·03	3·64	4·24
1100	1·67	1·33	3·00	1·33	2·00	2·67	3·33	4·00	4·67
1200	1·82	2·55	3·27	1·45	2·18	2·91	3·64	4·36	5·09
1300	1·97	2·76	3·55	1·57	2·36	3·15	3·94	4·73	5·51
1400	2·12	2·97	3·82	1·70	2·54	3·39	4·24	5·09	5·94
1500	2·27	3·18	4·09	1·82	2·73	3·64	4·54	5·45	6·36
1600	2·42	3·39	4·36	1·94	2·91	3·88	4·85	5·82	6·79
1700	2·58	3·61	4·64	2·06	3·09	4·12	5·15	6·18	7.21
1800	2·73	3·82	4·91	2·18	3·27	4·36	5·45	6·54	7·63
1900	2·88	4·03	5·18	2·30	3·45	4·60	5·76	6·91	8·06
2000	3·03	4·24	5·45	2·42	3·64	4·85	6·06	7·27	8·48
2100	3·18	4·45	5·73	2·54	3·82	5·09	6·36	7·63	8·91
2200	3·33	4·67	6·00	2·67	4·00	5·33	6·67	8·00	9·33
2300	3·49	4·88	6·27	2·79	4·18	5·57	6·97	8·36	9·76
2400	3·64	5·09	6·55	2·91	4·36	5·82	7·27	8·73	10·18
2500	3·79	5·30	6·82	3·03	4·54	6·06	7·57	9·09	10·60
2600	3·94	5·52	7·09	3·15	4·73	6·30	7·88	9·45	11·03
2700	4·09	5·73	7·36	3·27	4·91	6·54	8·18	9·82	11·45
2800	4·24	5·94	7·64	3·39	5·09	6·79	8·48	10·18	11·88
2900	4·39	6·15	7·91	3·51	5·27	7·03	8·79	10·54	12·30
3000	4·50	6·36	8·18	3·64	5·45	7·27	9·09	10·91	12·73
3100	4·60	6·58	8·45	3·76	5·63	7·51	9·39	11·27	13·15
3200	4·69	6·79	8·70	3·88	5·82	7·76	9·70	11·63	13·57
3300	4·77	7·00	8·86	4·00	6·00	8·00	10·00	12·00	14·00
3400	4·84	7·21	8·96	4·12	6·18	8·24	10·30	12·36	14·42
3500	4·90	7·31	9·06	4·24	6·36	8·48	10·60	12·7	14·85
3600	4·95	7·40	9·16	4·36	6·54	8·73	10·91	13·09	15·27
3700	4·99	7·48	9·24	4·48	6·73	8·97	11·21	13·45	15·69
3800	5·03	7·54	9·29	4·60	6·91	9·21	11·51	13·82	16·12
3900	5·06	7·60	9·34	4·73	7·09	9·45	11·82	14·18	16·54
4000	5·08	7·64	9·37	4·85	7·27	9·70	12·12	14·54	16·97

USEFUL TABLES

AVERAGE WEIGHTS OF RAW MATERIALS AND PRODUCTS

(per cubic foot and per bushel)

	Lbs. per cubic foot	Lbs. per bushel
CEREALS		
Maize (No. 2, Yellow American)	45	58½
Maize (Plate)	49	63
Barley (No. 2, Canadian)	36	46
Oats	29½	38
Wheat	47	60
Rye	43	55
Rice	47	60
Millet	42	54
Dari	51	66
Buckwheat	40	51
LEGUMINOUS SEEDS		
Beans (China Horse)	50	64
Soya Beans	43	55
Peas	49	63
Gram	47	60
Lentils	49	63
GROUND OIL CAKES		
Linseed	34½	44½
Cottonseed (decorticated)	37	48
Palm kernel	28	36
Coconut	29½	38
Ground-nut (decorticated)	39	50
Sesame	29½	38
Soya bean	35	45
Sunflower	33	42
Hempseed	29½	38
BY-PRODUCTS AND MISCELLANEOUS		
Weatings	23	29½
Bran	15	19
Pollards	14½	18½
Malt coombs	15	19
Brewers' grains	16	20
Distillers' grains	17	22
Dried blood meal	27½	37
Fish meal	39	50
Meat meal	39	50
Meat and bone meal	43	55
Bone meal	51	66
Molasses	83	107
Dried yeast	41	52
Maize germ meal	31	40
Maize gluten feed	34	44
Hominy chop	43	55
Barley meal	27½	37
Maize meal	36	46
Sussex ground oats	25	32
Cut corn	41	52½
Crushed oats	18	23
Bean meal	39	50
Flaked maize	12	15

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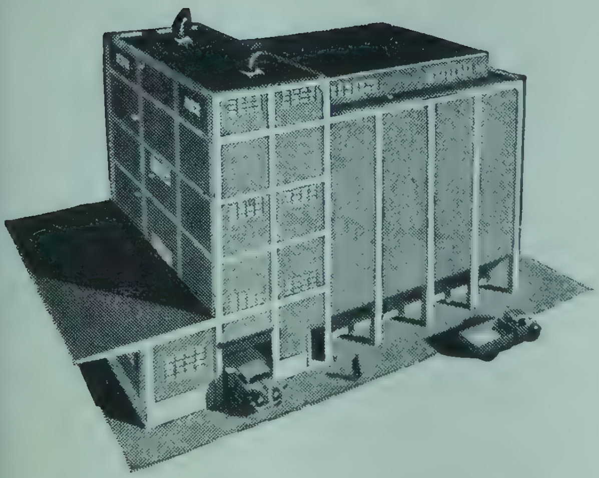

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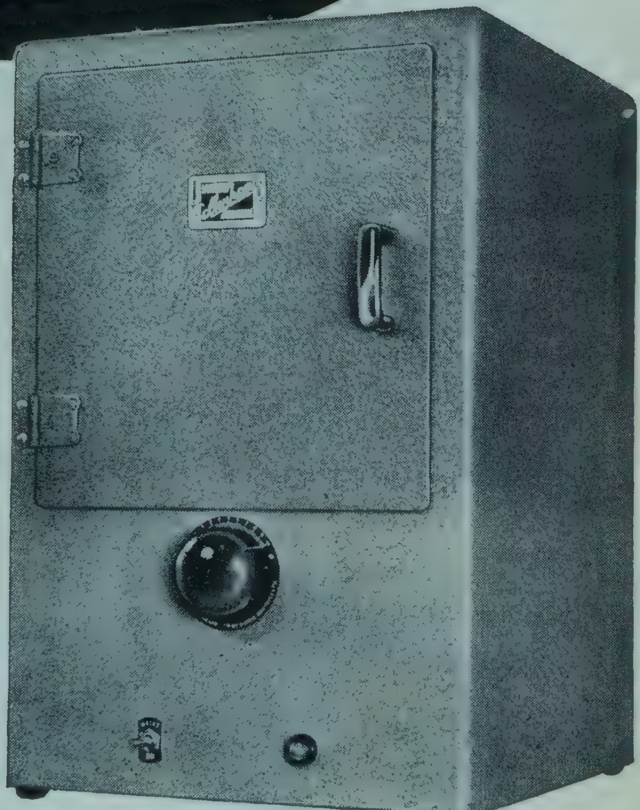

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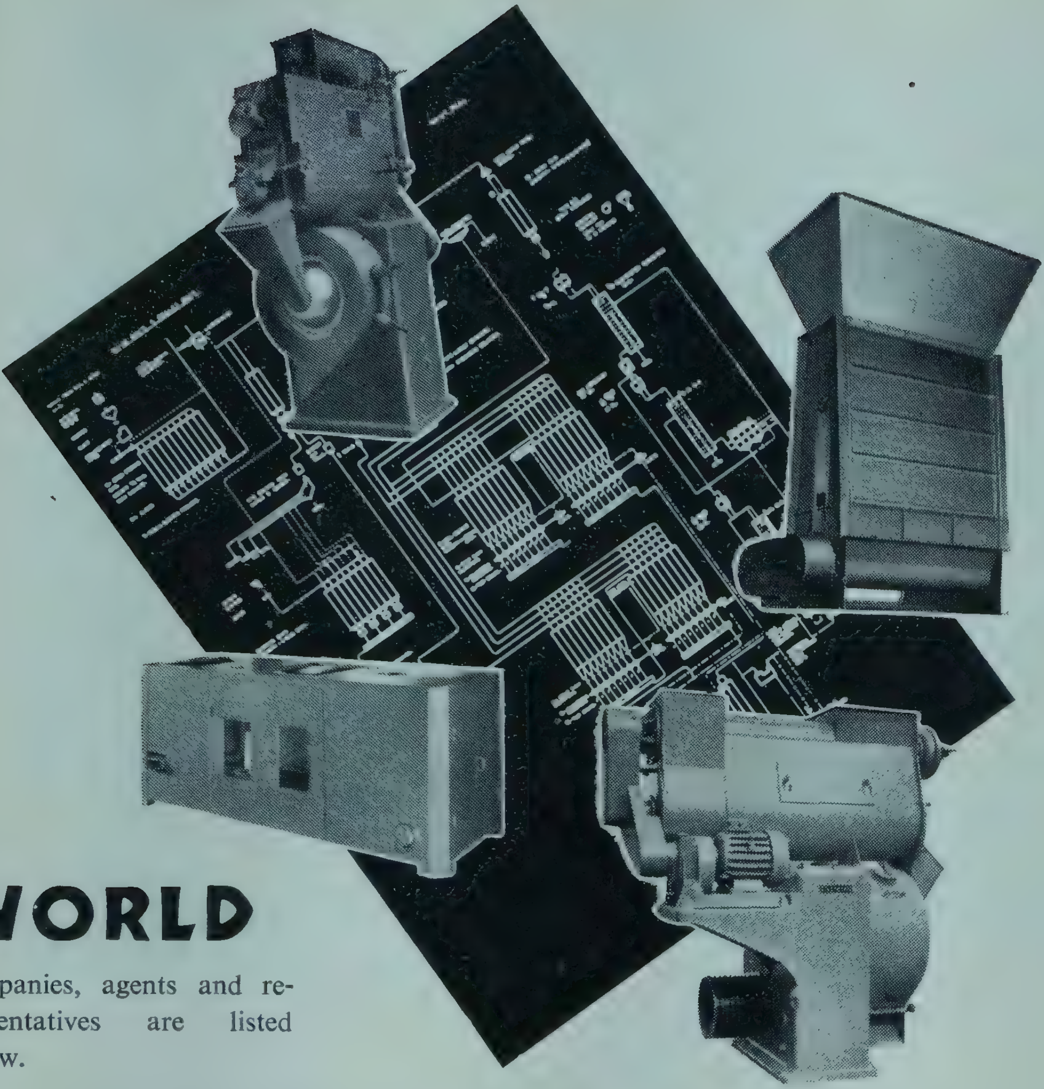

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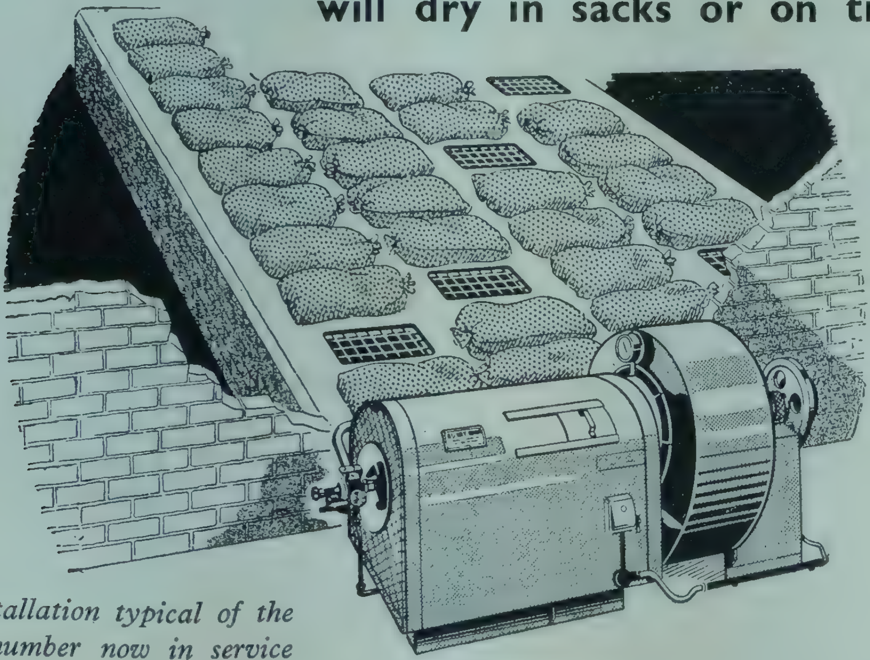

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Average fuel cost 2d. per cwt. dried

✶ **As reviewed in the Ministry of Agriculture Farm Machinery Leaflet No. 12**

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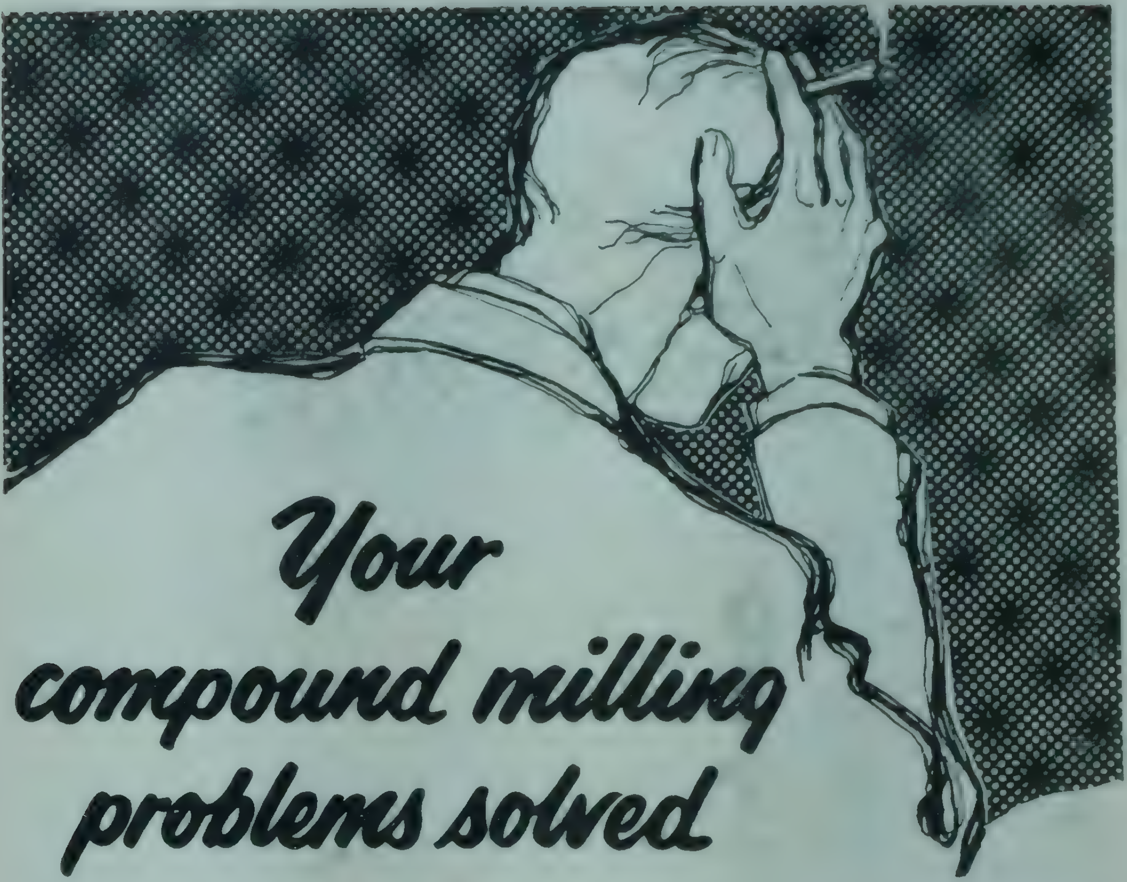
NU-WAY HEATING PLANTS LTD., DROITWICH, WORCS.


Your compound milling problems solved

ROBINSONS also offer those engaged in Compound Milling a complete service for the planning, installation and servicing of processing plant for feeding stuffs.

Your problem may appear difficult, but their technicians have probably met and cured one like it before.

And even if it's unique there's a special Research and Development Department to solve it. Remember, Robinson's "individual and objective treatment" has been proved successful by world famous firms.

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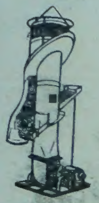
KAYBEE STANDS FOR MODERN MACHINES

THE MOST COMPREHENSIVE RANGE OF ULTRA MODERN MACHINES FOR THE CLEANING AT ALL STAGES FOR ALL PURPOSES OF CEREALS, PULSES, SEEDS ETC.

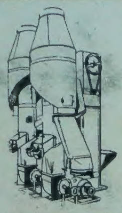
FOR ALL STORAGE AND HANDLING



"Scientaire"

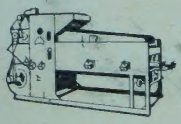
Pneumatic Pre-Cleaner

Capacity 5/6 tons per hour irrespective of moisture content



"Scientaire"

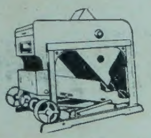
Duplex. For capacities of 10/15 tons per hour. Low power, small space, high efficiency



"Kaybee 50"

5 machines in one self contained unit

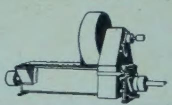
"Kaybee" General Separator



4 types, 20 sizes. Capacities 1 to 100 tons per hour

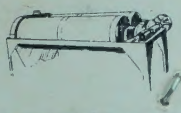
FOR SPECIALISED GRAIN, SEED & PULSE CLEANING

"Kaybee" De-awner, Thrasher, Clipper. Small size, high efficiency and low power. Indispensable for all combine harvested crops



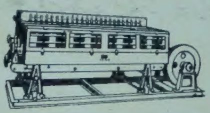
"Kaybee" High Capacity Cylinder

The modern method of separating by length. Capacities from 500 to 10,000 lbs. per hour.



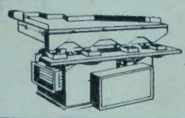
"Kaybee" Table Separator

10 sizes, capacities up to 10 tons per hour. Built in variable speed drive

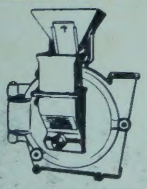


"Kaybee" Gravity Separator

The machine with many specialised applications on cereals, pulses, seeds, etc.

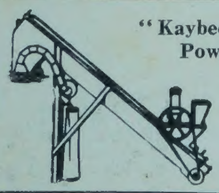


FOR THE COMPOUND & PROVENDER MILLER.



Type "K" Hammer Mill

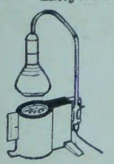
with built on magnetic separator and efficient store trap. Employs new principles



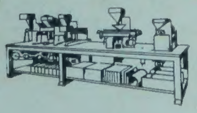
"Kaybee" Type "B" Powder Dresser

3 sizes, 1 to 6 tons per hour capacities

"Kaybee" Infra-red Moisture Tester



Accuracy with speed. Determinations from 0% - 100% to within ± 0·5%



"Kaybee" Laboratory Cleaning Plant

5 separate testing machines

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BILBROUGH, YORK
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The above are just twelve out of a range of over 100 modern machines specially designed for the cleaning and preparation of all types of cereals, pulses and seeds. Send for full particulars of these or of our complete range of rice, flour, barley, oat and provender milling machines. A complete Seed Testing Laboratory is at your service for testing and investigating your problems.

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